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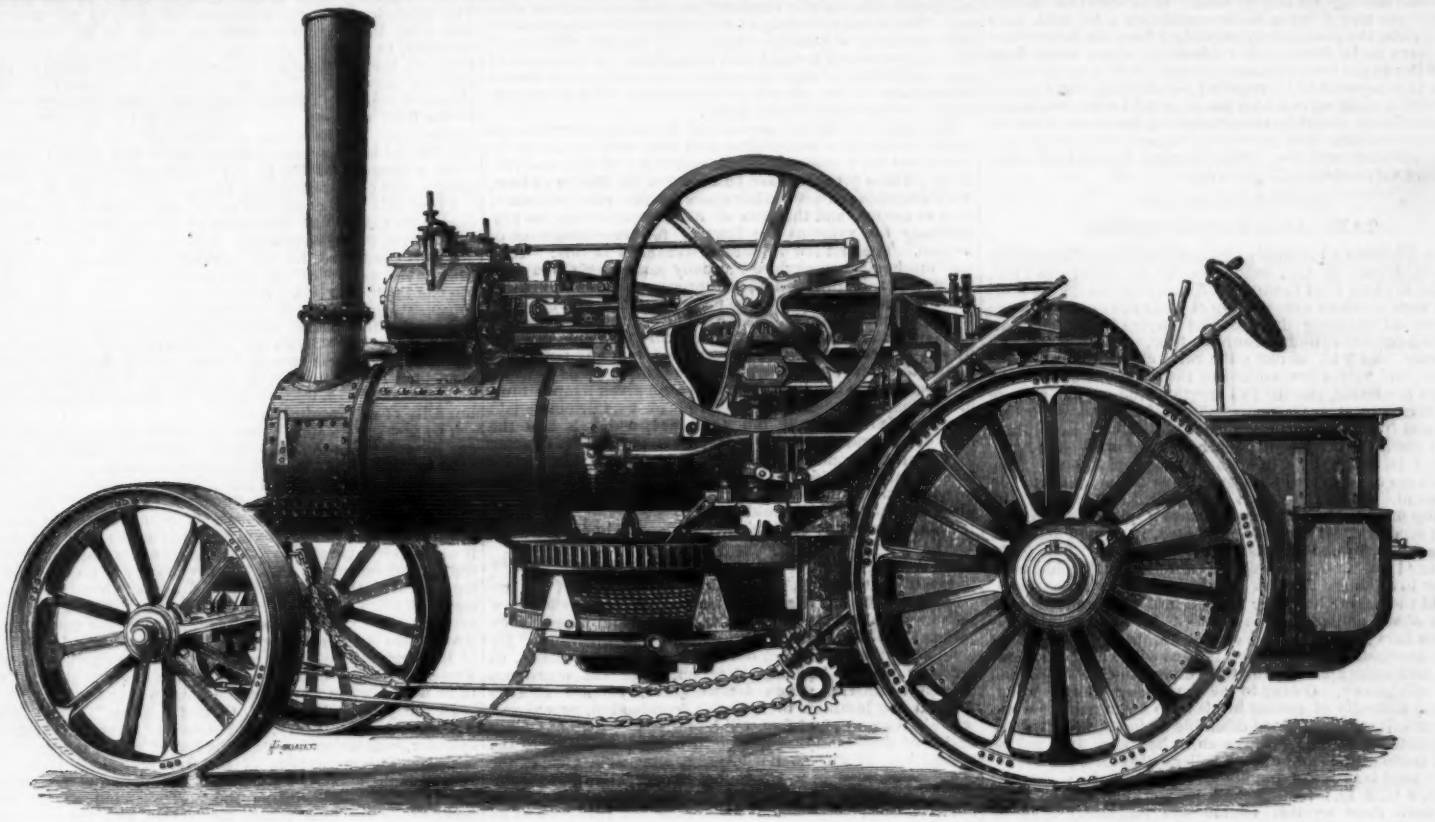
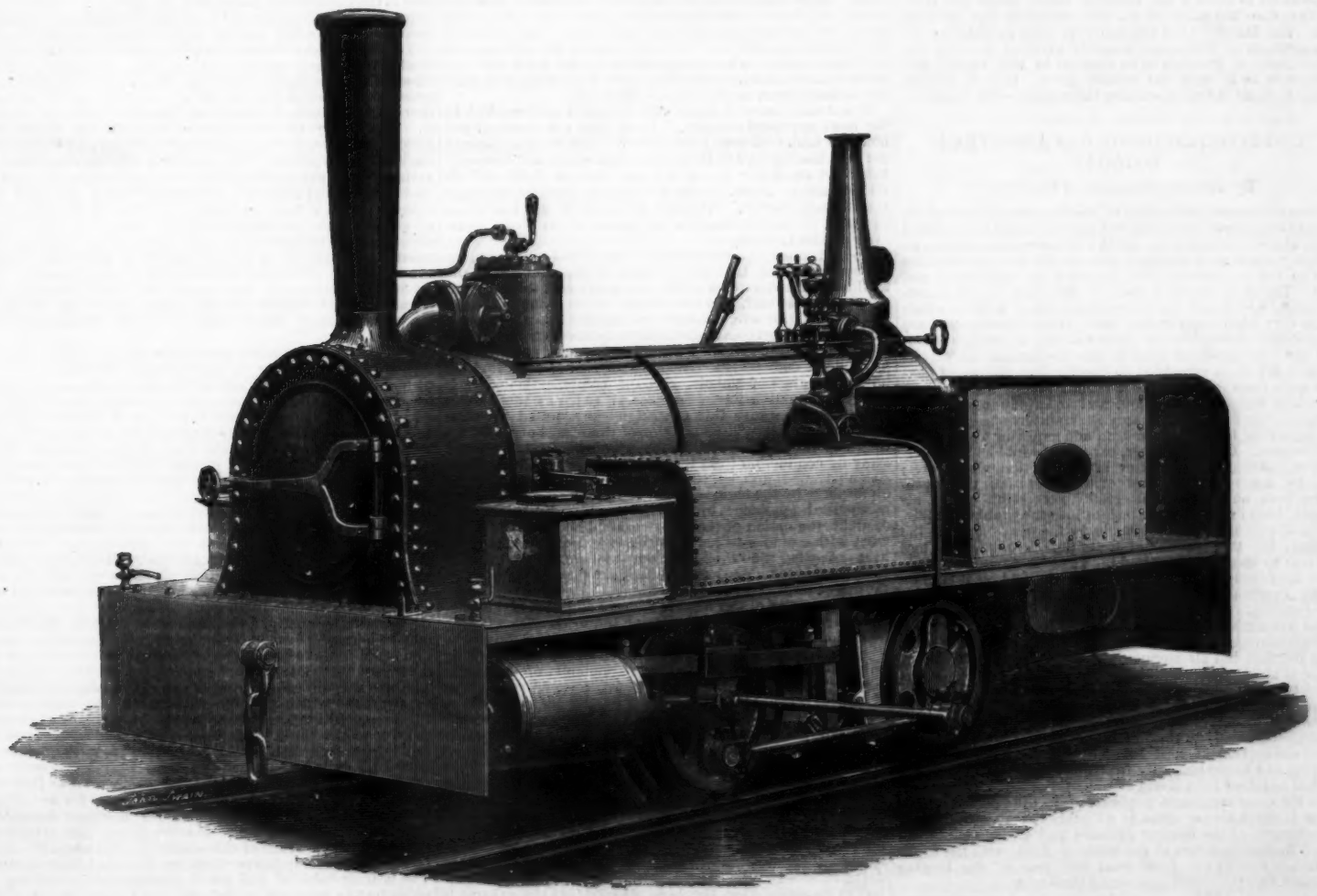


IMPROVED SIXTEEN-HORSE COMPOUND STEAM PLOWING ENGINE. (See next page.)



IMPROVED TANK LOCOMOTIVE. (See next page.)

IMPROVED STEAM PLOWING ENGINE.

MESSRS. John Fowler & Co., of Leeds, have for some time past been strong advocates of the compound engine, and this year at the Smithfield Agricultural show they exhibited nothing else, the 16-horse steam plowing, the B class traction engine, and 8-horse semi-fixed engine which they exhibited being all of the compound type. Of the plowing engine we give a view on first page, which will show its general design The two cylinders are placed side by side with the valve chest above them, the valve spindles being inclined as shown. The arrangement of the plowing gear calls for no special comment, as it is of Messrs. Fowler's usual design, and a thoroughly good job. The makers speak very highly of the results obtained with compound engines for steam plowing work, and they are steadily introducing them in place of their former single-cylinder patterns. The road locomotive and the semi fixed engine beneath a boiler of the locomotive type are of patterns which we have described on former occasions. The boilers of all the engines are of steel, and steel is also largely used in other parts, while for the brackets malleable castings are largely used. We notice that Messrs. Fowler are now forging their crossheads solid with their piston-rods, the pistons being detached from the latter when they have to be drawn. For admitting steam direct from the boiler to the low-pressure cylinders of their compounds, when this happens to be required for starting, there is now provided a small valve which has to be held open, but which is immediately closed by the pressure of the steam when the handle is released, thus preventing engine-drivers from carelessly running with live steam passing direct to the low-pressure valve chest.—*Engineering.*

TANK LOCOMOTIVE ENGINE.

WE illustrate a locomotive designed and manufactured by J. & G. Joicey & Co., engineers, of Newcastle-on-Tyne, for the M'ckley Coal Company of that city, for taking coals from their crushers over the top of their coke ovens for the purpose of charging them. The engine is of the four-wheeled outside cylinder coupled type, cylinders 4½ in diameter and 9 in. stroke; the valve chests are inside the frames, and valves are worked in the usual manner. The frames are inside, run the full length of the engine, and are well stayed by cross transoms; the boiler barrel, outer fire-box, and front tube plate are made entirely of Low Moor iron; the inner fire box of copper, tubes of brass; the gauge of rails is 3 ft. 6 in.; the wheel base is 2 ft. 9 in. The wheels are of cast iron, with steel tires 20 in. diameter on the tread. A constant feed is supplied to the boiler by a pump fixed to the front cross transom plate, and worked by an eccentric. This is supplemented, in case of accident, to the pump, by one of Giffard's brass injectors. Side tanks are fitted to keep the weight as low as possible; and with a view to minimize the risk of damage to working parts, should the engine leave the rails—a not unfrequent occurrence about colliery wagon ways—it is fitted with single motion bars; the advantage of this has already been several times demonstrated. The engine is fitted with a novel and powerful foot brake applied to all the wheels, which is simple and very satisfactory. Owing to the small size of the boiler, and the difficulty of getting inside to do any repairs to working parts, it was considered desirable to have the regulator valve outside, and, as will be seen, it has been fixed on the small dome at the front end of boiler. (See first page.)

The total length of engine over all is 9 ft.; extreme width, 5 ft. 3 in.; total weight in working trim, 3 tons. The work done by this engine was previously done by manual labor, which was very slow, and consequently costly. One man was able to charge fifteen ovens per day, at a cost of 4s. 2d., or £65 per year for wages. Since the engine was set to work it has charged ninety ovens per day, and thus does the work of six men, and with the greatest ease. The Mickley Coal Company is now completing its arrangements for fitting one hundred ovens of its very extensive range at Prudhoe to be charged by this engine, and so satisfied is it with the results given, that it intends shortly to do all charging work by this means.—*The Engineer.*

THE EFFICIENCIES OF GAS AND STEAM MOTORS.*

By THOMAS HOLGATE, of Burnley.

THE economical production of motive power has long occupied the minds of engineers and scientists, and has resulted in the almost exclusive use of the steam-engine, which, although perfect as a machine, has an efficiency of working fluid so low as scarcely to be regarded as satisfactory and final. The main cause of the low efficiency of the steam-engine is to be found in the employment of a fluid which has a very high specific heat, and which requires to have its physical state changed before it can be made to convert the heat expended upon it into mechanical work. As the heat which is expended in causing the change of physical state from this liquid to a vapor is about six-tenths of the whole heat of evaporation, and is largely rejected by the steam into the exhaust, many attempts have been made to use liquids of lower specific heat, and requiring less heat for evaporation. Of these, ether, carbon bisulphide, and mercury have been used alone or in conjunction with water; but, by reason of the cost of the material, these processes have not been commercially successful. Other attempts, based upon a truer insight into the problem requiring to be solved, have been made by the use of a gas as the medium for the transfer of heat; thus avoiding the loss incident to the use of a liquid. The gas which has been most frequently used is atmospheric air; and, as it is practically a permanent gas, it is so far admirably adapted for the purpose. Its slow specific heat, however—which is about one-sixth that of water—renders it necessary to work at high temperatures, if much energy is to be developed.

In the first hot-air engines, a fire was applied to the exterior of a cylinder containing air; and another cylinder was provided, into which the heated air was allowed to expand, propelling a piston as in a single-acting steam-engine. Very few of these engines have been brought into practical operation, owing chiefly to the difficulty of obtaining a sufficiently rapid convection of heat to and from the mass of air employed, and to the necessity for using a more bulky cylinder than is required for a steam engine of the same power and with the same maximum pressure. The diffusion of heat in a gas is much slower than in a liquid, and accordingly the temperature of the heating cylinder had to be maintained much higher than that of the working fluid, with the result of failure due to the great wear and tear of the heating cylinder and the valves connected therewith.

In the air-engines designed by Captain Ericsson, the efficiency of the working fluid was 0·25, while the efficiency of the furnace was nearly 0·4; making a resultant efficiency of the fluid and furnace of 0·1, which is about the same as that of a modern steam-engine. According to Professor Rankine, the efficiency of the working fluid in the Stirling hot-air engine was 0·3, while the efficiency of the furnace was 0·44. To overcome the slow heating of the air, when in mass, has been the object of many inventors; and a type has been proposed with a closed furnace, and the air forced through the furnace, keeping up the combustion, the hot products going to the motor cylinder and there doing work. An engine of this kind was made and worked experimentally by Sir George Cayley; but the cylinder, piston, and valves were found to be so rapidly destroyed by the intense heat, and the dust from the fuel, that no attempt was made to bring it into practical use.

The most recent development of air-engines employing internal combustion is that known as the gas-engine. In this type of engine the working fluids used are practically perfect gases, and the diffusion of heat through the mass is obtained by the use of a combustible gas in conjunction with air. The intimate contact of the combustible components with the air to be heated is so complete, that the diffusion of the heat generated is rapid and immediate. A statement of the capabilities of this last-named motor, together with a comparison of its efficiency and economy with the steam-engine, is the object of this paper.

Any machine which converts heat into work or mechanical energy is termed a heat-engine, and may have its action investigated by a reference to the principles of thermo-dynamics. These principles are based upon the theory of heat, which regards the immediate cause of the phenomenon of heat as motion, and the laws of its communication, as precisely the same as the laws of the communication of motion. The first law of thermo dynamics is this: "Heat and mechanical energy are mutually convertible, and heat requires for its production, and produces by its disappearance, mechanical energy in the proportion of 772 foot-pounds for each unit of heat." The second law of thermo-dynamics is this: "It is impossible for a self-acting machine, unaided by any external agency, to convey heat from any portion of matter to another at a higher temperature." The measure of the greatest possible efficiency between given temperatures in any heat-engine may be determined by a principle laid down by Sadi Carnot in the year 1824, which is that the ratio of the amount of work done by a perfect heat engine to the work expended upon it depends only on the constant temperatures at which heat is received and at which it is rejected, and is independent of the nature of the intermediary agent or working fluid.

This statement is conveniently embodied in the formula $\frac{T-T_1}{T}$, where T represents the absolute temperature of the source of heat, and T_1 the absolute temperature of the refrigerator. By this relation we shall be able to ascertain how far our actual engines deviate from the maximum efficiency assignable between the working limits of temperature. By comparing the work given out in the working cylinder, as recorded on an indicator diagram, with the maximum efficiency between given temperatures, we are able to find out the loss due to radiation, conduction, or exhaust waste. An important fact will be seen by a further examination of this relation, together with a consideration of the second law of thermo-dynamics—namely, that some of the energy contained in a gas cannot be converted into useful work, because the entire abstraction of heat from the molecules of any body would necessitate the reduction of its temperature to the absolute zero—a degree 460 below the zero of the Fahrenheit scale, and apparently unattainable. The energy is present as heat, but it cannot be utilized, because "it is impossible, by means of inanimate material agency, to derive mechanical effect from any portion of matter by cooling it below the temperature of the coldest of the surrounding objects." I shall speak of the efficiency of any heat-engine, when compared with the total heat expended, as the absolute efficiency, and when compared with the available heat, as the relative efficiency.

In a steam-engine of large size, designed and worked in the most approved manner, 2 lb. of coal are required per hour for each indicated horse power. The heating value of the coal used is 30,000 British thermal units, and the equivalent of one-horse power for one hour is 2,565 British thermal units. From this we find that the absolute efficiency is about one-twelfth. Turning to see how this loss is occasioned, let us first consider the action of the steam generator and its furnace.

The efficiency of a steam-boiler is measured by comparing the heat delivered into the cylinder of the motor with the total heat of combustion of the fuel used; and this is found to be about one-half. So low a result is due to the following facts: First, for every volume of oxygen drawn into the furnace to support combustion four volumes of inert nitrogen are received, resulting in a diminished temperature of the products of combustion. Secondly, by using solid fuel, an intimate contact of the air with the combustible matter is practically unattainable. In general, twice as much air is admitted to improve this contact as is required for complete combustion. The admission of this excess of air lowers the temperature of the hot gases. Thirdly, heat is carried away by conduction from the surface of the fuel, boiler, and steam passages, and by the gases as they escape into the atmosphere by the chimney. By the use of a fan or other mechanical appliance in place of a chimney to cause a draught, the action of the furnace could be improved somewhat with a moderate reduction in the quantity of waste heat. Further than this, however, it is improbable that any considerable reduction of these losses will take place while the use of solid fuel continues.

The efficiency of the fluid in a steam-engine is about one-sixth, and is obtained by comparing the work done with the heat contained in the steam when admitted into the working cylinder. The low efficiency of the working fluid is mainly due to the larger amount of heat contained in the steam when it is rejected from the cylinder. This heat is not shown by the indication of a thermometer, while the water is in the state of steam; but is shown when the heat is given up to the condensation water, and is present in the liquid. It is usually spoken of as latent heat. This heat is required to maintain the fluid as steam, and is there present as internal work, enduing the molecules with a greater or less velocity according to the temperature, and thereby enabling them to do *external* work. When the physical state is changed from a vapor to a liquid, this internal work is changed to heat which is sensible to the thermometer, but which has lost its power of doing external work. If we consider the engine to be perfect in its action, then the heat rejected into the exhaust is determined by the back pressure, which is dependent on the temperature of the condenser and the perfection of the action of the air-pump.

Taking the initial pressure at 115 lb. absolute, and the back pressure at 3 lb. absolute (or, as usually expressed, 12 lb. vacuum), then the heat utilized will be—

$$\frac{T-T_1}{T}=\frac{800°-560°}{800°}=\frac{3}{10}=0·3,$$

and the heat rejected, seven-tenths of the whole heat contained in the steam as delivered into the cylinder. If we take the initial pressure to be 350 lb. absolute, and the back pressure to be 3 lb. as before, then the heat utilized is equal to—

$$\frac{892°-560°}{892°}=\frac{332}{892}=0·37,$$

and the heat rejected = 0·63. The amount of heat converted into external work is generally, however, only one-half that possible under the conditions of maximum efficiency which we have just been assuming. The actual efficiency of the working fluid is then brought down to one-sixth. This deviation from the maximum efficiency of the fluid is due, first, to conduction from the walls of the cylinder; secondly, to initial condensation of the steam caused by the range of the temperature through which the metal of the cylinder passes; and, thirdly, to the loss caused by the clearance volume. The only direction in which the efficiency of the fluid is likely to be improved is by increasing the temperature of the steam as delivered into the cylinder. Within the last few years attempts have been made to work with a pressure of 350 lb. per square inch above the atmosphere, and corresponding to a temperature of 436° Fahr.

From this brief consideration of the action of the steam-engine we gather that the causes of its low efficiency are to be found in the unsatisfactory way in which the chemical action is conducted for the generation of the heat, and the unsuitable nature of the intermediary agent—water. To obviate these objections, repeated attempts have been made to construct an engine in which the heat shall be supplied by the combustible matter within the motor cylinder, and in which the intermediaries are permanent gases. Petroleum vapor and coal gas have both been used as the combustible element, with air in suitable proportions to act not only as a supporter of combustion, but as a diluent to modify the intensity of the resultant action.

The first engine embodying the use of these gases, which can lay any claim to notice, is one invented about the year 1863 by M. Lenoir. In this motor air and coal gas in proper proportions are introduced into a cylinder; the admission is cut off; and the mixture exploded by electricity. The explosion causes a sudden increase of temperature and pressure; the gaseous mixture expands, driving the piston before it until the outstroke is completed, and is then expelled during the return stroke. The irregularity of the ignitions, together with the large quantity of gas required, prevented the extensive adoption of this motor. The maximum pressure, in some cases, was obtained near the end of the stroke, just before opening the exhaust port, instead of being at the beginning of the stroke. The experiments of M. Tresca, of Paris, show the consumption of gas in this engine to be 93 cubic feet per indicated horse power per hour.

In the year 1866 the "Otto and Langen" engine was patented in this country. It consists of a very tall vertical cylinder, containing a piston, the rod of which is formed as a rack. The mechanism of the fly-wheel shaft is so arranged that the rack on the piston rod does not gear with the fly-wheel shaft during the upstroke, but during the downstroke the rack comes into action, and the fly-wheel shaft is rotated. The action within the cylinder is this: Upon commencing the upstroke, the piston acts as an exhauster, drawing in a mixture of gas and air. This mixture is then ignited by means of a gas jet placed outside the cylinder. The pressure and temperature within the cylinder increase very quickly, and the piston is sent rapidly to the top of the cylinder without causing rotation of the shaft. Owing to the large amount of expansion, and to the cooling effect of a water jacket round the base of the cylinder, the pressure falls below that of the atmosphere, and the piston descends by reason of atmospheric pressure upon the top of it. The energy of the explosion is stored up within the piston during the upstroke, and made to do duty by its gravity during the downstroke. The explosive mixture consists of 1 volume of coal gas and 9 volumes of air. This engine was much more economical than any gas engine which preceded it, being reported to have a consumption of about 30 cubic feet of gas per hour per indicated horse power. It has been superseded on account of the noise it caused in working, the repairs necessary to an engine subject to such shocks, and the large size of engine required for a small power. To remedy the defects of this engine, Mr. Otto invented the silent gas engine which bears his name, and which has been largely adopted by small users of power throughout the country.

It consists of a cylinder, into which gas and air are drawn through suitable valves by the forward movement of the piston. On the return stroke of the piston the mixed gases are compressed to a volume equal to 1-2·18 of that originally occupied. The piston is now at the end of its return stroke, and the combustible mixture is ignited by means of a gas-flame which is burning at the rear of the cylinder. The temperature and pressure of the ignited gases increase rapidly, and the piston is sent forward by the expansive action. When the piston reaches the end of its outstroke the exhaust valve is opened, and the major part of the products of combustion are ejected into the atmosphere; the rest are allowed to stay within the cylinder, and serve to dilute the charge for the next ignition. These inert gases serve also to form a cushion upon which the sudden increase of pressure from the combustible mixture is received, and by their expansion gradually convey the pressure to the piston. By this arrangement of Otto's engine the working fluids can only be admitted into the cylinder at each alternate revolution of the crank-shaft. The admission of air and gas is controlled by a slide-valve placed at the rear of the cylinder. The quantity of gas allowed to enter is regulated by a pair of governors, which shut the valve when the speed of the engine exceeds a fixed limit, and open it again when the speed is reduced below that limit. The slide-valve serves also to convey a light from a fixed light to the mixture within the cylinder.

The quantity of gas used by these engines varies from 22 cubic feet per hour per indicated horse power for an engine of 15-horse power, to 18 cubic feet per hour per indicated horse power for an engine of 40-horse power. In our calculations of the efficiency of this engine we will adopt 22 cubic feet as the consumption per hour per indicated horse power. The heating value of coal gas is variable, but by taking 1 cubic foot to be equal to 505,000 foot-pounds, we shall be adopting a value very near the average found in most towns.

* A paper read before the Burnley Literary and Scientific Club, Oct., 1887.

The absolute efficiency, then, of our gas-engine is found thus—

$$\frac{60 \times 33{,}000}{22 \times 505{,}000} = \frac{198}{1111} = 0{\cdot}178;$$

showing an absolute efficiency twice as great as that of a large and economical steam-engine.

Turning now to ascertain what is the greatest possible efficiency of this gas motor, we come face to face with the complex question of the behavior of the combustible mixture within the cylinder. The action (according to Mr. Otto, the inventor) may be described as follows: Air and gas are introduced at atmospheric pressure into the cylinder, and are mixed with the inert gases which were left from the previous charge. Coal gas is 1-13 of the volume; but that portion of the charge nearest the piston is least combustible, being comparatively inert. This mixture is compressed to about 45 lb. per square inch absolute, and then ignited. No explosion, as generally understood by that term, occurs; but a combustion takes place at the rear of the cylinder, and this combustion gradually spreads toward the front. The heat from this action is conveyed to the comparatively inert portion (or cushion) of the charge, and expands it, thus avoiding shock. This slow combustion is obtained by having a dilute mixture otherwise incombustible, but made to be combustible by the compression, and which propagates the flame comparatively slowly, attaining complete combustion as the flame spreads.

Until recently this was the view taken by experts of the action within the cylinder; but that this is open to correction there seems to be little doubt. In a very able contribution read before the Institution of Civil Engineers, Mr. Dugald Clerk has propounded a theory of the gas-engine in which dissociation forms a very important factor. According to experiments made by this gentleman, using various mixtures of gas and air, the highest temperature he has usually been able to obtain in the cylinder of his engine is 1,537° C. If chemical action took place at high temperatures as at low temperatures (or, in other words, if combustion or combination of the elements was unchecked by high temperatures), then the temperature which ought to be attained is 2,440° C.; but, from experiments made by Bunsen, Deville, and others, on the combination of hydrogen and carbon with oxygen at various temperatures, we are led to believe that the chemical actions possible at low temperatures are impossible at temperatures above a certain limit for each compound, called the "point of dissociation." The following experiment conducted by Clerk shows this in a clearer light. A cylinder 9 inches long and 9 inches in diameter was filled with a mixture of 1 part of coal gas to 5 parts of air, which is the proportion for maximum explosive effect. The temperature of the mixture before ignition was 12° C; the highest temperature attained after explosion was 1,864° C., corresponding to an absolute pressure of 112 lb. per square inch as measured by a loaded valve of known area. If complete combination had taken place, then the temperature should have been 2,862° C., corresponding to an absolute pressure of 163 lb. per square inch. This experiment, which is in accord with others, tends to show that the chemical action was checked when the temperature attained was considerably less than the calculated one. In order, therefore, that temperature and pressure may be maintained up to the adiabatic line, fresh supplies of heat must be generated within the cylinder. This process can only take place by combination of the elements, made possible by the forward movement of the piston increasing the volume and reducing the temperature below the limit of dissociation. The rate of transmission of the flame through the mass is about 1-50 of a second, and the attainment of maximum temperature indicates the complete inflammation of the mass. Although the rate of increase in temperature is very rapid immediately after the ignition, the rate of decrease from maximum temperature is very slow; showing that the spread of the flame is complete when the maximum temperature is reached.

I have thus briefly stated the most recent investigation into the working of the gas motor, not because it very materially alters the greatest possible efficiency, but because it shows the complex chemical action which will have to be borne in mind in any attempt at improved working. The total heat given to the fluid is the same whether dissociation takes place or not; but the way in which the heat is supplied and the range of temperature are affected by it. The maximum efficiency of a motor using 22 cubic feet of gas per hour per indicated horse power—employing a mixture of 1 of gas to 12 of air, compressing before ignition, and expelling the products of combustion at the usual temperature, viz., 430° C.—is 0·74; being a maximum efficiency 4½ times that of a good steam-engine.

The temperature due to the gas present, assuming no dissociation and no change in specific heat, is 2,440° C. Then—

$$\frac{2440 - 430}{2440 + 273} = \frac{2010}{2713} = 0{\cdot}74;$$

1 lb. of gas equals 30 cubic feet, and is equivalent to 10,900 thermal units centigrade; 1-13 of a cubic foot of gas = $\frac{10{,}900}{390}$ = 27·9 thermal units centigrade. Also 12-13 of a cubic foot of air = 0·0692 lb.; 1-13 of a cubic foot of gas = 0·0025 lb. The specific heat of air at constant volume is 0·169.

$$\frac{27{\cdot}9}{0{\cdot}17 \times 0{\cdot}0717} = \frac{27{\cdot}9}{0{\cdot}012189} = 2290° \text{ C.}$$

Add initial temperature 150° C., highest temperature = 2440° C. As, however, it is possible to attain a lower temperature of the exhaust gases by a larger amount of expansion than is at present practiced, a higher maximum efficiency may be taken. If the expansion is carried down to 200° C., then the maximum efficiency = $\frac{2240}{2713}$ = 0·82. But although we have this high possible efficiency of 0·74, the absolute efficiency we have seen to be only 0·18; being a relative efficiency of 0·243. This low relative efficiency is mainly due to the large amount of heat carried away by the water in the jacket surrounding the cylinder.

The following table shows how the heat delivered to the engine is disposed of:

	Dr. Slaby, of Berlin.	Professor Kennedy.	Mr. Dugald Clerk.
Amount converted into work	16·0	18·6	17·83
Abstracted by cooling water	51·0	51·9*	52·89†
" " expelled products	31·0	29·5	29·28
" " conduction and radiation	2·0	—	—

* Unaccounted for. † Cooling water and conduction.

These numbers, which were obtained from separate experiments, are singularly confirmatory of the character of the motor's working. It is more than probable that the heat lost into the exhaust will be largely reduced by adopting a greater amount of expansion; but how to reduce the loss caused by the water jacket is not so clearly seen.

I have already stated that the consumption of gas in motors of 40 indicated horse power is less than the quantity we have based our calculations upon, being 18 instead of 22 cubic feet for the 15-horse power motor. This is due to less abstraction by the cooling water, for the capacity of a cylinder increases as the square of the diameter, while the surface of the metal in contact with the hot gases is only in direct proportion to the diameter. Improved working will result from the employment of larger cylinders, and from greater expansion; so that we may reasonably expect to obtain 1-horse power per hour from 12 cubic feet of gas. The best results will be obtained by using a cylinder which is maintained hot (having no water jacket), and to which the entering gases are supplied hot. To work with a hot cylinder will necessitate a piston which does not accurately fit the cylinder, and preferably one which is made of a non-conducting material. To increase the temperature of the entering gases, the heat contained in the expelled products will be absorbed by a regenerator, and then given up to the entering gases as they pass to the cylinder. A motor constructed upon these, the most approved principles, has been invented by Dr. Siemens, but has not yet been largely adopted. The mechanical difficulties are much greater in this than in the cold cylinder engine; but now that so many minds are turned to the consideration of this motor, these difficulties may reasonably be expected to be surmounted.

The gas motor is comparatively new, yet since the year 1863 the cost of working has been reduced to one-sixth. The principal reason for this improvement is to be found in the compressing of the charge before ignition. By compression it becomes possible to have a greater degree of expansion with the same size of cylinder; it enables a larger amount of heat to be converted into work by any small movement of the piston (thus making the power more mechanically available); and it also reduces the time of contact of the hot gases with the walls of the cylinder. The compression in the "Otto" engine is 30 lb. per square inch, and in the Clerk engine 40 lb. per square inch. The following example will serve to show the importance to be attached to compression:

First, take a motor in which compression is not used, and in which the maximum temperature is 1,537° C. Let the volume of the mixed gases drawn into the cylinder be 0·4 cubic feet. The maximum pressure immediately after ignition will be 91·6 lb. per square inch absolute. When the gases have expanded to a volume of 0·6 cubic foot, or 1½ times their original volume, the pressure will be 51·75 lb.; when expanded to 1 cubic foot, the pressure will be 25·2 lb. per square inch absolute; and when expanded down to the atmospheric pressure (say 15 lb.), the volume will be 1·446 cubic feet:

Degree of Expansion, Cub. ft.	Work done by Fluid, Foot-Pounds.	Work done on Atmosphere, Foot-Pounds.	Work done on Piston, Foot-Pounds.
From 0·4 to 0·600 ..	1973 ..	423 ..	1550
" 0·4 to 1·000 ..	4038 ..	1270 ..	2768
" 0·4 to 1·446 ..	5276 ..	2259 ..	3017

Therefore the theoretically available work obtained from 1 cubic foot when expanded to 2½ cubic feet is 6,920, and when expanded down to atmospheric pressure is 7,542 foot-pounds.

Secondly, take now a motor in which compression is employed, and in which the maximum temperature is the same as before—viz., 1,537° C. Let 1 cubic foot of combustible mixture be drawn into the cylinder, and compressed to a volume of 0·4 cubic foot. The pressure will be 53·42 lb. After ignition the pressure will be 229 lb. per square inch absolute. When the gases have expanded to 0·6 cubic foot, the pressure will be 129·4 lb., when expanded to 1 cubic foot, it will be 63 lb.; and when the atmospheric pressure is reached, the volume will be 2·773 cubic feet:

Degree of Expansion, Cub. ft.	Work done by Fluid. Foot-Pounds.	Work done on Atmosphere, Foot-Pounds.	Work done on Piston. Foot-Pounds.
From 0·4 to 0·600 ..	4·927 ..	423 ..	4,504
" 0·4 to 1·000 ..	10,094 ..	1270 ..	8,824
" 0·4 to 2·773 ..	17,648 ..	5021 ..	12,627

The work done in compressing from 1 cubic foot to 0·4 cubic foot is 2,353 foot-pounds. Therefore the theoretically available work obtained from each cubic foot is 7,741 foot-pounds when expanded to the same volume as before compression; and 17,648 — (2,353 + 3,751) = 11,544 pounds when expanded down to the pressure of the atmosphere. From the figures given in the first column for each case, we see that the work done by the fluid for equal movements of the piston is proportional to the mass of the gaseous mixture.

In the compression engine we use per charge 2½ times the fuel used in the non-compression engine; and the rate of conversion of heat into work is in the same proportion. The figures have been obtained by the annexed formulæ, which are for *adiabatic expansions:*

$$\frac{t}{t_0} = \left(\frac{v_0}{v}\right)^{\gamma-1} = \left(\frac{p}{p_0}\right)^{\frac{\gamma-1}{\gamma}}, \text{where } \gamma = \frac{0{\cdot}238}{0{\cdot}169} = 1{\cdot}408$$

the ratio of the specific heat of air at constant pressure to its specific heat at constant volume.

$$w = \frac{1}{\gamma - 1}\left\{p_0 v_0 - p\, v\right\}$$

where w is the work done in foot-pounds in expanding from v_0 to v.

The points to be noticed in this example in favor of the compressing engine are—(1) the greater amount of work obtained before atmospheric pressure is reached; (2) the greatly diminished area and time of contact of the hot gases with the walls of the cylinder. If our arrangements were absolutely perfect, we ought to obtain the same power from a given volume of gaseous mixture, whether we use compression or not. But we find that the heat is rapidly carried away by the cooling water, and it therefore becomes desirable to lessen this loss by a rapid conversion into work. Another great advantage is that we obtain higher pressures. We may obtain increased expansion by using a vacuum pump; but it is more convenient in practice to compress before ignition. More perfect arrangements for the ignition and controlling the supply of the combustible element have also contributed to improved results.

At the present time the cost of fuel alone in working a steam-engine is less than the cost of coal gas for a gas-engine, owing to the fact that the latter has undergone a process of preparation, and that it is not yet called for in sufficient quantities to enable its price to be greatly reduced. The selling price of gas is largely determined by the interest to be paid on capital, and by the cost of distribution. If the consumption of gas during the daytime were largely increased, the price could be reduced, because the total charges for distribution and interest on capital would not be materially affected; the cost of the increased quantity being (say) 1s. 2d. per 1,000 cubic feet. It has been proposed by the engineer of the Leeds Corporation Gas Works to supply gas at this price for gas motors. Counting on a largely increased sale, he has shown that in his particular case this is possible. At the price named, fuel may be supplied to the gas motor almost as cheaply as to the steam motor; while the many other advantages of the former will command its extensive adoption.

For engines of not more than 40 indicated horse power there are pecuniary advantages in favor of gas, more especially if the power is required intermittently. Other advantages there are of considerable value—(1) convenience of starting and stopping; (2) greater cleanliness; (3) small amount of attention required; (4) greatly diminished risk of explosions; (5) no smoke nuisance. Instead of using coal gas in these motors, it has been proposed to use a gaseous mixture of carbon monoxide, nitrogen, and hydrogen, known as the "Dowson gas," which is made by forcing air and a little steam through incandescent anthracite coal. Partial combustion of the carbon in the coal takes place, each atom of carbon uniting with one of oxygen from the air or from the steam. The hydrogen resulting from the decomposition goes forward as such with the carbon monoxide and nitrogen of the air. This mixture is found to have a calorific power one-fifth that of coal gas, and is stated to cost 3½d. per 1,000 cubic feet. The anthracite used is 1½ lb. per indicated horse power. As this price does not cover any charge for distribution, but is merely the cost on the premises of the producer, it is not strictly comparable with the cost of coal gas. In the use of the Dowson gas some of objections to a steam generator are still retained, especially that of frequent attention. Taking this price, however, and comparing it with the price at which large quantities of coal gas can be supplied, the comparison is in favor of the latter. The distinctive feature at present of the coal gas motor is its readiness for action immediately it may be required. This makes it peculiarly valuable as a pumping-engine in case of fire in a factory or warehouse, and for intermittent work anywhere that its fuel is available.

Thoughtful minds are at the present time being turned to a study of the action of gas motors, and it is scarcely too much to expect that during the next few years their action will be greatly improved. With the price of gas gradually diminishing, the use of these motors is rapidly extending, and it is not improbable that the predictions of eminent engineers will be realized in the substitution of a motor in which the furnace and cylinder are combined, and in which gaseous fuel is employed, instead of the unsatisfactory but not unworthy steam-engine.

I wish to express my obligations to Mr. Dugald Clerk, for information obtained from his paper on the "Theory of the Gas-Engine," and to Mr. F. W. Crossley, for the figures obtained in the experiments conducted by Dr. Slaby, of the Royal Technical School, Berlin.

THE TRAINING FOR STUDENTS IN CIVIL ENGINEERING.*

By GEORGE L. VOSE.

THE remark has recently been made that, while civil engineering is a *business* of great antiquity, it has only recently become a *science*. Without stopping just now to ask whether engineering has in reality become a science, we may very properly inquire whether anything that can correctly be called engineering science has made the business any better, or has enabled us to produce any better practical results; and, if so, in what that science consists. I ask these questions, as they seem to me to lie at the foundation of a correct understanding of what we should teach, and how we should teach it in the engineering school. To know how to teach, we should know first of all what we are required to teach, and what results we are expected to produce. These we learn best by a careful examination of the methods followed and the works constructed by our leading engineers.

We find at the outset that civil engineering in the United States is somewhat different from that in Europe, and in many respects very properly so. To have attempted in this country to carry out the methods followed in Great Britain and on the Continent, would have soon put a stop to all internal improvements in America. The rapid and enormous development of the United States is due not simply to the railroad system, but to the *American* railroad system. Our early self-taught engineers at once saw that with our very limited means, and our vast extent of territory, a very much cheaper kind of engineering would have to be adopted for this country than was followed in the densely populated parts of Europe, where money was plenty and the territory was comparatively small. If we look at the works of Smeaton and Brindley, of Rennie and Telford, of Brunel and the Stephensons, we find a kind of engineering eminently English, eminently substantial, eminently expensive. The docks of Liverpool and London, the splendid roads of Wales, the stone bridges and viaducts throughout the kingdom, almost without number, the harbors and breakwaters, the works for drainage and reclamation of land from the sea, the older canals, and more recently the enormous network of railways, with their elaborate structures of iron, brick, and stone, all bear witness to the energy and the skill of English engineers, but all at the same time illustrate a very costly kind of engineering. If we look at the engineers of the earlier works in Great Britain, we shall find a very large proportion of them to have been self-taught men, men who arose from the ranks—masons, blacksmiths, bricklayers, carpenters—men with but little of what we call education, and little, or perhaps nothing, of what we call science, but men of indomitable courage, infinite patience, well trained judgment, and unbounded common sense, who by long years of persistent toil put themselves at the head of the world's engineers.

If we look now at the early engineering of the United States, we find that the requirement here was quite different from that in Europe. We were very fortunate in this country in possessing good natural seaports, and were thus saved the expense of the artificial harbors which have made so noted a feature in foreign engineering. There was found in North America a land traversed by magnificent natural water courses, furnishing ready made means of communica-

* Read October 18, 1882, before the Boston Society of Civil Engineers.

tion, which for a long time were quite sufficient for the purposes of our interior commerce. Civil engineering in the United States may be said to have commenced with the building of the Erie Canal, the construction of which first called out our native talent, and produced our pioneers in the profession—Benjamin Wright, James Geddes, and Canvass White. The rapid spread of the canal system into Pennsylvania and Ohio produced many other admirable engineers; but the advent of a new mode of transport soon put a stop to canal work, and gave us the fathers of railroad engineering in the United States—Gridley Bryant, Jonathan Knight, Benjamin H. Latrobe, Charles Ellet, John B. Jervis, John Childe, Wm. Gibbs McNeil, and George Whistler. Many of the most noted among these early engineers were, like their English brothers, entirely self-taught men, who had to feel their way along cautiously through the untried field of engineering work; and all of them owed their success mainly to their own indefatigable exertions, aided by strong native talent, and not to anything that could properly be termed engineering science or engineering education. There has been no more admirable feature in American engineering than the manner in which these early engineers adapted themselves to the requirements peculiar to our country, and moulded their practice to the conditions imposed upon them. The long range of the Appalachian Mountains, lying as a barrier between the great central basin and the Atlantic coast, made an enormous draught upon the energy, skill, and patience of the fathers of the American railroad system, and well was that draught honored by the engineers of the Baltimore and Ohio, the Pennsylvania, and the Erie railroad. Not only have the methods employed by the engineers of those early roads given to this country the backbones of our system of interior communication, but they have served for examples the world over, as models for railroad location.

We may stop here a moment to note the fact that all through the early engineering of both England and the United States there was no such thing as any school for training the civil engineer. There was no such thing as a science of civil engineering. Engineering was in some sort a craft, but not a recognized profession. The works of internal improvement were comparatively limited in extent, and the demand for engineers was not larger than could be supplied by men of strong natural powers, with enthusiastic love for their work, men who had the genius to originate, and the ability and the perseverance to find out what they did not know.

To come down a little later, we find the construction of public works rapidly increasing, and a corresponding increase in the demand for engineers. Many young men, drawn to an occupation which is always attractive to persons of a practical turn of mind, found employment as assistants to surveyors and engineers, and gradually the system of apprenticeship arose, under which a young man, wishing to become an engineer, entered an office for a fixed time, and paid a premium for learning what he could. Of course, as a general thing, no attempt was made to teach him, but he was expected, or at any rate allowed, to keep his eyes open, and to see what was going on. About this time, too, a few books upon engineering matters began to show themselves, and the shelves of the offices furnished such food as Pambour on the Locomotive, Wood on Railroads, Vicat on Cements, Parnell on Common Roads, and the like. These works made very little attempt to be scientific, but were largely descriptive of actual works, and were thus valuable.

Foremost among institutions designed especially for the training of engineers was the Polytechnic School at Paris. In this school it was recognized that civil engineering was largely a mathematical business, and it seemed to be assumed at the start that if a little mathematics was good, more mathematics was better, and the most mathematics was the best; and many leading minds in that eminently mathematical nation set to work to reduce engineering to a mathematical science, and volume after volume upon the location of roads, the stability of retaining walls, the transportation of earth, the application of descriptive geometry to the construction of masonry, and other like matters appeared, in which all the resources of the higher mathematics were exhausted, and which showed the authors to possess every accomplishment except, perhaps, a little common sense. In establishing the earlier schools in this country, it was quite natural to look to the pioneer school in Paris, and in many places a system was imported not at all adapted to any practical engineering in this country, if indeed it was to that in any country. The fact that under such a system good engineers have been produced means nothing, as the same may be said of no system at all. We are not to judge a system of instruction by a few brilliant exceptions, but by the general average. While we may justly admire the great works of foreign engineers, and while we have much to learn from their practice, at the foundation our system is better for us than any other; and we shall do better to let the plant which is native to our soil grow naturally, than to graft foreign branches on to it. The attempt to transplant the French system of engineering instruction into the United States has not been a success. American engineering is the best engineering for this country. Our students are to be American engineers, and we must fit them accordingly.

But, it may be asked, is not this rather a narrow view to take? Is not geometry the same the world over? Is not the strength of a piece of iron the same in the United States as elsewhere? Are not the fundamental principles of engineering the same in all countries? Most undoubtedly they are. But, we may reply, the varying conditions under which we are to apply the fundamental principles of engineering may make it advisable to do very differently in one place from what we would in another. I stood a good many years ago with an English engineer upon the site of the present Niagara suspension railroad bridge, and I told him that it was proposed to carry railway trains across that river. He replied that it could not be done, because a tubular girder of 800 feet span, if strong enough, would fall by its own weight, and that a suspension bridge could not be made stiff enough to carry a railway train. The geometry and the iron of the English engineer were the same as those of Mr. Roebling, but Mr. Roebling had the genius for meeting a new problem, which the latter had not. The whole progress of engineering in this country has been a perpetual illustration of the successful solution of new problems. The very facts which to one man are an impassable barrier, become in the hands of another the very means of success. The grades and curves which by foreign engineers were pronounced impracticable, if not impossible, in the hands of Mr. Latrobe were made to perform one of the greatest feats of modern engineering.

In deciding what course we shall follow the best to train the young engineer we see at once that we have to do two things—to make him an engineer and to make him a man. The more symmetrically we develop our man the better the result will be, even in a special direction. Far too little attention has been given in our technical schools to anything like general education. Just as a variety of food is best for physical health, so is a variety of study best for mental health; and just as we need a foundation of the best general physical health in order to train a man for physical exertion in any particular direction, so do we need a basis of good general mental health in order to train a man for mental exertion in any special line. "A thorough technical education," says a recent writer, "embracing all that science and art can bestow, is not enough to produce the best industrial results. There is need of the additional discipline which comes only from the study of letters. The man must be *formed* as well as *informed* before he is fully educated, even for practical purposes." Many years ago the Bavarian Council for Roads and Bridges decided on admitting into the body of government engineers none but those who before entering the Polytechnic School had followed a complete classical course. The Administration of Mines had also constantly required the same qualification. A better illustration of the thoroughly and symmetrically trained engineer can nowhere be found than the late Baron Weber, perhaps the best railroad expert the world has ever seen. He commenced with a thorough classical training; next he passed through the Polytechnic School at Dresden; he then received a practical training, first as a pupil and afterward as constructor in the locomotive works of Borsig at Berlin, at the same time attending university lectures in political economy and the natural sciences. Finally he commenced his practical railroad course, beginning as locomotive engineer and working up through all the technical and administrative positions to the office of General Manager; and later, having traveled through all civilized countries on a tour of inspection of public works, became Councilor to the German Empire.

We see at once that in laying out any course of study we are to keep in view a double object. We are to drill the student, and to give him useful information. Some studies furnish excellent discipline, but are of little or no practical use; others are useful, but do not afford much discipline; while others again at the same time accomplish both of the above results. "Every branch of study," said the late Dr. Wayland, "should be so taught as to not only increase our knowledge, but also confer valuable discipline; and it should not only confer valuable discipline, but also increase our knowledge. If it does not accomplish both these results, there is either some defect in our mode of teaching, or the study is imperfectly adapted to the purposes of education." Studies more especially for discipline should, as far as possible, come early in the course, while studies more for use should come later, as, having already the discipline, the student makes better progress. As one of our prominent engineers has put it: When a student has learned how to learn, he can quickly learn anything.

The study of mathematics has always taken a prominent place in engineering courses, and very properly so; but it is after all the more simple and elementary part of mathematics that is of the most use to the engineer. Recent discussions upon the subject of the training for civil engineers have called out some very decided opinions from authorities who are certainly competent to express themselves in this matter. "Much time," says Mr. Thomas C. Clark, "is wasted in our colleges and technical schools over the higher mathematics. Every engineer will agree with me that the cases where the use of the higher calculus is indispensable in our practice are so few that its study is not worth the time expended on it; and we have the highest authority for saying that unless its use is constantly kept up we become too rusty to use it at all." "It is true," says Mr. Fuertes, himself an accomplished professor of civil engineering, "that there are very few cases in which the engineer needs the higher analysis; that not one in a hundred uses it at all; that it cannot possibly be applied unless we are quite familiar with it; that, like correct fingering on a musical instrument, it makes severe demands on our time; and that it is easily forgotten, because much of its machinery is dependent on forms or processes that must be memorized for instant choice when needed." "Practical engineers," says Mr. Charles Bender, himself an accomplished mathematician, and a graduate from a German university, "generally do not place much confidence in long formulæ; and if they once have studied mathematics thoroughly, they lose the taste for these studies after some time of practice, since they have convinced themselves of the futility of ultra-refined theoretical speculations." "In our experience of nearly half a century as an engineer," says Mr. Julius W. Adams, "we have very rarely found that engineers possessing this peculiar facility for minute mathematical analysis, with the consequent reliance upon its infallibility which usually accompanies it, were safe guides, either in the design or execution of novel projects."

Many persons seem to think that if we can put anything into mathematical language, we have done all that is necessary; that the mathematical mechanism can take the place of actual facts; that the lever is enough without the applied power. "We must not," says a recent writer "confound mathematical skill in the making and manipulating of formulæ with science. There is a vast difference between the misuse of the higher mathematics and the proper use of those mathematical principles which lie at the foundations of all engineering operations." Mathematical skill must be tempered with a good deal of judgment before it can be of any very great use. It has been said by those who admit that the higher calculus is of little actual service to the engineer, that while it may not be really necessary for use, it is very desirable for discipline. This sounds quite well, but it is very doubtful if the average student gets from the study of the higher calculus the discipline that he is supposed to. It is very easy to deceive ourselves into believing that the student *does* get what by our theories he *ought to* get. Not many years ago the custom was very general in our colleges to oblige all students to go through the differential and integral calculus. This was done purely on the ground of discipline, for no one ever claimed that it was to be of any use to the student. It was found, however, after many years, that except in rare cases, the student utterly failed to get any return at all commensurate to the amount of time given to this study. For the great number it was merely an inducement to shirk duty, and a means for getting slovenly habits of study. It is now almost universally abandoned as a required study in colleges. The fact is now recognized that much better discipline is had by doing a more simple thing well than by doing a difficult thing badly. To a certain extent a person must have mathematical genius to do good work with the higher calculus. An old mathematician being asked by what rule he performed a certain operation, replied, "By the rule of Gumption;" and it is certainly the fact that the inventive faculty, nay, even the imagination, enters as a larger and larger factor in the mathematics as we climb to higher and higher planes in that science. It has been said of the poet that he is born, not made. It may be said of the mathematician that he must be both born and made. Mathematical talent of a high order is rare, and any system of instruction that is based upon the assumption that all students can profitably spend a large amount of time upon an extended course of advanced mathematical work, I believe to be a faulty system. On the ground that we should do the greatest good to the greatest number, I hold that we should make our course in engineering study useful rather than difficult. It is much more important to make the student very familiar with the more simple things that he is going to use, than to cram him with the more difficult things that he will never use. Our instruction should be adapted to the average of good students, and not to a few exceptionally bright ones, always endeavoring, of course, to raise the average, and always providing advanced work for those who can take it. The school should be like a good garden for hardy plants, and not like a hot house for forcing an unnatural growth. Mathematics is called an exact science, and those who have but little experience are apt to think that any mathematical operation must of necessity produce an exact result. This over-reliance on mathematical processes is a sure sign of inexperience. Only when the mathematical mechanism is applied to the right facts and with correct judgment do we get reliable results.

It is well understood among engineers that all ordinary engineering problems, mathematically considered, are quite simple. Look at any of our great engineering works, and see how much mathematics was needed to carry it out. Take from civil engineering all that the higher mathematics has ever done for it, and see how much it would be damaged. See what one of our great works we should lose, if the calculus had never been invented. A short time since there was held at Washington an examination for the position of civil engineer in the navy. Government wanted four civil engineers. The number of applicants was very large, for the position was a good one, and a permanent one. The candidates were subjected to a long and searching competitive examination, conducted by five expert civil engineers. There was not a question from beginning to end that involved anything beyond the most elementary knowledge of mathematics or mechanics. The examination was marked throughout by fairness and common sense, the desired result being to get, not an engineering scholar, but a man who would be of the most use to the government as a sound, practical engineer.

It is certainly not advisable to consume too much of the student's time in mathematical discussions of engineering questions, for not only are such discussions of little or no practical use, but the pupil acquires a habit of regarding all engineering problems as capable of solutions far more exact than is possible, considering the defects inherent both in materials and workmanship. A grave defect in our mode of instruction is that instead of fitting the student to deal with engineering problems *as they are*, we fit him to deal with these problems *as mathematicians assume them to be*. A glance at any of the ordinary text-books will show how much more they are mathematical than practical. The market has been flooded during the past ten or twelve years with more or less mathematical works upon bridge building, but we shall look a good while in these books for any information of practical use that we did not possess before. Had we more books like Clarke's description of the Quincy bridge, or Chanute's work on the Kansas City bridge, we should be a good deal better off than we are; but, strangely enough, we have to go to Europe for the best published illustrations of our own engineering works. The tendency of many recent writers to indulge in mathematical recreations has produced works far more interesting to the authors than valuable to engineers. We can hardly wonder, from the general aspect of many of the papers in our professional magazines, at the remark of one of our oldest and best engineers, that science seems to consist in burying the simplest facts completely out of sight under heaps of mathematical rubbish; or the criticism of another of our professional veterans, that such methods seem very much like using a sledge hammer to break an egg.

The idea that has sometimes been expressed that an engineer must at any time be able to go to the foundation of any formula which he may have to use, shows simply an entire lack of appreciation of the work an engineer has to do. Indeed, many of the formulæ are found upon examination to have no foundation on which any reliance can be placed. A very large part of the rules in the books have been made, not by engineers, but by mathematicians, or by mere engineering scholars; and however admirable they may be as specimens of mathematical reasoning, they are of little or no use in practice. Take the whole matter of stone arches, of retaining walls, of dams, of the pressure of earth work—the results of the higher analysis are for the most part of no practical value whatever, and serve only to confuse and disgust the student with what, treated in a simple and practical way, may be made both useful and interesting. One of our most distinguished engineers has said with a good deal of truth that "Trying to apply the higher mathematics to engineering is like looking into the clouds with a telescope of high power in search of facts within our grasp on the surface of the earth."

"If," says the late Milnor Roberts, "it was required to designate the one essential requisite of an engineer, we would place *judgment* first. An engineer to be great or strong must have other qualifications, but lacking that essential element, judgment, he would be incapable of availing himself even of brilliant talents." This point is of so great importance that I may be permitted to quote a few lines from a very masterly address delivered by the late Professor Faraday before the Royal Society of London, on the Education of the Judgment. "A great deficiency," says Mr. Faraday, "in the exercise of the mental powers in any direction, is deficiency of judgment. Failure to draw correct conclusions comes far oftener from error of judgment than from error of sense. I believe that the judgment may be educated to a very large extent. There is one point in this education of the judgment which is very important, and very difficult to deal with, because it involves an internal conflict. It consists in the tendency to deceive ourselves regarding all we wish for, and the necessity for resistance to all these desires. It is impossible for any one who has not been constrained by the course of his occupation and thoughts to a habit of continual self-correction to be aware of the amount of error in relation to judgment arising from this tendency. The force of the temptation which urges us to seek for such evidences and appearances as are in favor of our desires, and to disregard those which oppose them, is wonderfully great. The inclination we exhibit in respect of any report or opinion that harmonizes with our preconceived notions can only be compared in degree with the incredulity we entertain toward everything that opposes them. I believe that point of self-education which consists in teaching the mind to resist its desires and inclinations until they are proved to be right is the most important of all. One exercise of the mind which

largely influences the power and character of the judgment is the habit of forming clear and precise ideas, so that vivid and distinct impressions of the matter in hand may remain. In like manner, we should accustom ourselves to clear and definite language, giving to a word its true and full but measured meaning, that we may be able to convey our ideas clearly to the minds of others. When the data have been collected, and we have succeeded in forming a clear idea of each, the mind should be instructed to balance them one against the other, and should not be allowed carelessly to hasten to a conclusion. Again, we should drill ourselves to being able to form a *proportionate* judgment. The mind naturally desires to settle on one thing or another, and that with a degree of absolutism which is irrational and improper. In drawing a conclusion it is very difficult, but not the less necessary, to make it *proportionate to the evidence;* and in some cases the exercise of the judgment ought to end in absolute reservation." In commending these words of Mr. Faraday to the student, we may add the not less important advice of a distinguished English geologist, Sir Henry La Beche: "It can only be amid a thousand errors, and by a determination to abandon our preconceived opinions when shown to be untenable, not by pertinaciously adhering to them because we have once adopted them, that we can approximate toward the truth. By strictly advocating a particular theory, prominently displaying the facts only which appear to afford it support, we are in perpetual danger of deceiving ourselves and others. Facts of all kinds, whether in favor of or against our views, should be honestly brought forward, in order that those whose opinions are unprejudiced may fairly weigh the evidence adduced." The world has just lost a man who was remarkable for absolute freedom from prejudice and for absolute perfection of judgment; and we as engineers may well learn from the greatest of modern philosophers, who during twenty years of intense labor persistently withheld his judgment, but patiently accumulated the facts upon which the doctrine of evolution now firmly stands.

In all our training of the engineering student, it is to be kept in mind that we are not only to give him the best standard information for his future use, but we are also to give him as for as possible the power of acquiring information, and of knowing how to use it when he gets it. Above all, we must not narrow nor distort his mind by partial training, so that after his studies are completed he will have to spend half a dozen years in unwarping it. We must rather give his mind that healthy elasticity that shall enable it to maintain its true form under all conditions. We are not to furnish the student with blue glasses nor with green glasses, but with white glasses, through which he shall see things as they are. We should also use every means to make the pupil as he progresses rely more and more upon himself. It will, perhaps, be asked if we expect to give the student anything that will take the place of natural talent. We never can find anything to take the place of hard work; we never can find anything to take the place of devotion to duty; we never can find anything to take the place of honesty; but we can find something, which, as far as it goes, will take the place of natural talent—*i. e.*, artificial talent, or education. The numbers of engineers possessing any very decided engineering genius is and always will be small. The great mass of the profession will always be, as it always has been, composed of men of average ability, who rely largely upon a thorough training for their business. The engineering works in this or in any other country which show brilliant genius are quite few. The greater part are not works of genius, but of good, practical, business capacity.

Suppose I should take a young man to give him private instruction in civil engineering. How would I go to work? Would I put Weisbach or Rankine into his hands, and tell him to read those books? Not at all. I would take him out with the transit and level. I would show him how the simplest things were done, and I would make him do them himself over and over again until he knew the practical detail thoroughly. Then I would show him the mathematical principles underlying that much practice; and little by little I would make him rely on himself for his methods of proceeding. Next I would show him some of the materials he is to use. I would take him to the quarry, to the brick-kiln, to the rolling mill, and the foundry, and have him see the process of obtaining the materials of construction. I would show him where and how these materials are employed in engineering works. He should thus find what tension, compression, cross strain, and shearing mean. He should see these materials broken under various conditions. He should learn by inspection what the fracture of various kinds of iron indicates. He should learn to judge of the quality of materials by actual contact with these things. Next, I would show him how these various materials are combined in engineering structures, with the apparatus used in such work. I would have him note carefully all of the practical details of building, the mixing of mortars and cements, the laying of brick and stone. I would keep him ever on the watch for bad workmanship and faulty methods. I would be especially careful to call his attention to any defective structures, to any signs of failure, and make him find the reasons for such defects. I would have him at every point note carefully the difference between the methods of the workman and the methods of the books. He should find, what the workman rarely, if ever, does, the *reasons* for his methods. At the time he is thus laying the foundation of the facts of engineering, I would step by step show to him the mechanical principles underlying those facts. I would not bother him with fine-spun theories in regard to the strength of materials, the theory of elasticity, or the stability of structures; but I would show him simple modes for doing simple things. I would never for a moment let him suppose that there was such a thing as a conflict between practice and theory. I would so train him that he should never regard science and art as two separate things, but rather as two parts of one and the same thing. After he had got steady on his legs, I would gradually bring him to see more complex and difficult problems. I would show him plainly that many problems are quite indeterminate, and that often a purely empirical method of solving a problem is not only sufficient, but is better than any other. Above all, I would train him in such a way that he should learn to know, as Lord Bacon has put it, "the relative value of knowledges." Finally, I would take every possible means to make him well poised and absolutely honest in judgment.

We cannot, of course, deal with large classes as we would with an individual, but we can certainly approach the method. At all events, we need not go out of the way to invert the mode. Our courses of study assume all students to be alike. This is to a certain extent necessary; but as the pupil advances the work may be made more and more individual, to some extent; we may thus fall in with Nature and work with her, instead of pushing against her. We must not only be sure that the right subject is presented in the proper manner and at the right time, but we must remember that to have the matter properly presented is only half the work. It must also be properly received. The great mass of students are always able to understand any ordinary subject when it is properly presented, and we must make sure as we go along that the pupil actually gets what we intend he should. No two students are alike; each has his own difficulties, each looks at a subject in his own way; and not only is it quite proper that he should, but the general progress of a class is far more satisfactory from this difference in its members than it would be were they all alike. The result of our course should be not so much to have made the student read certain books, as to make him able to do certain work. A man may have Weisbach and Rankine by heart, and yet know little or nothing of engineering; he may apparently have a perfect knowledge of all the books, and yet have no real knowledge of the subject.

We can in teaching make a subject repulsive or we can make it attractive. There is a vast difference between simply hearing lessons and giving instruction. The duty of an instructor is not merely to unload all the knowledge he has at the student's door, never waiting to see that he takes it in and uses it. We are not to regard the engineering student as a school boy, but we are to take him by the hand and make a companion of him. There should be always attraction between the teacher and the pupil, never repulsion. The study of civil engineering cannot be made easy, but it can be cleared of unnecessary obstructions, and I regard it as a prominent part of our duty to do this. We have got to work and to make the student work; but we must work along the line of least resistance. We want our labor to produce useful result, and not to be wasted in overcoming friction.

We often hear it stated that the business of the school is not to deal with details, but with what are somewhat vaguely termed general principles. I believe there never was a greater fallacy. No general principle can possibly be applied to engineering construction except by means of practical details; and in many cases the details are more important than the principles. I believe that just as engineering practice preceded engineering science, so in our course of instruction we must have a soil of practical conceptions in which the theoretical plant can grow. To give a young man an exhaustive theoretical discussion in the school, and to tell him that by and by he will run across the practical details, is very much like setting out a plant upon a brick sidewalk, and trusting to luck to get some earth about its roots at some future time. We can stop in the school to study and discuss details with the student, but it is not the business of an employer in actual work to instruct his assistants, and he never does it. I don't mean to say that experience can be taught in a four years' course, but there are a great many results of experience that can be presented to the student which will save him a vast deal of time and trouble, and at the same time show him exactly what his work is like. There is nothing more important than that the student should be made to see very plainly that no mechanical philosophy whatever can be applied to practice which is not subject to the unavoidable imperfections of materials and of workmanship, and I hold that one of the most important things we have to do in the school is to show how far the contingencies of workmanship limit the applications of science. We should make the connection plain between the science of engineering and its practical applications. We should give the student that knowledge of practical details which shall enable him to modify his theoretical knowledge in accordance with the requirements of practice. For lack of this the student wastes his time. The practitioner blunders along without the aid he might have, and a fancied conflict appears between two things, neither of which can do its best without the aid of the other.

It has sometimes been said that the work of the school is not so much to enable a young man to be at once serviceable to his employer, or profitable to himself, as to lay the foundation on which he can build the highest professional character hereafter. This remark would seem to indicate that these two results are in some way discordant. If engineering is properly taught, there can be no possible conflict here. There is no reason why the same process should not produce both of these results. There is no possible reason why the instruction should not be given with a view to immediate usefulness, and at the same time be given in such a manner that it can be expanded to any desirable extent.

There is one point upon which I am very particular not to be misunderstood. I do not wish to be thought in favor of omitting the study of any part of the higher mathematics. I am not one of those who think that nothing should be taught unless we can see in it some immediate use. I make no objection to the time given in our engineering schools to descriptive geometry. It is of no practical use. Very few engineers know anything about it, and those who do never use it; but I regard it as one of the best studies we have for discipline, as it develops a faculty in the student which is reached in no other way. The modern languages again are not essential for the engineer. I know the theory is that he reads the French and German engineering works. I know equally well the fact that he does not. For all that I regard the study of the modern languages, or of any language, as of great importance to all students, and I should value it as a most useful part of the education of an engineer, though I knew that he would never use it in his life.

It is very necessary that the student should be taught to be careful about little things, and not to think, because he may be all right in the matter of general principles, that the details will look out for themselves. It would, indeed, be more correct, in many cases, to say: Look out for the details, and the general principles will take care of themselves. On the other hand, the student should learn, what is not less important, when *not to be exact*. He should learn that a lack of method is sometimes preferable to too much method; that very often a purely empirical mode is better than any other. It is in many cases neither bad engineering nor bad logic to assume a solution for a problem and verify it afterward. We might, perhaps, make a general rule for finding the position of a slope stake in a side-hill cutting, but we can put the stake in by the common mode of trial a good deal quicker than we could apply a general formula.

In laying out our work in the engineering school, it is very important to make the course comprehensive. We owe this not only to the students, but also to the school; for by so doing, we not only deal more fairly with the young men, but we insure a more steady supply of students, as we make the school more independent of fluctuations of special departments of engineering business. Many of our schools seem to have assumed that the subjects of railroads and bridges cover the whole field of engineering, and ignore entirely the matters of hydraulics, water supply for cities, sanitary work, drainage and irrigation, river and harbor work, and other equally important branches. Especially do the schools appear to have neglected altogether any endeavor to make of the student a good business man. There can certainly be no more important exercise for the engineering pupil than the careful study in detail of well made specifications, of contracts, and of the strictly business portion of engineering operations, and certainly nothing has been more completely neglected. We graduate young men who are more or less familiar with the mathematics, chemistry, physics, geology, astronomy, but quite unable to examine the simplest accounts of a contractor, or to judge in any way of the economy with which any work is being carried on. The power to handle large bodies of workmen, and to obtain the greatest useful result from a given expenditure of money, is no doubt very largely a natural gift; but a very useful amount of this power can certainly be gained by close study and careful attention to detail, and this point should at all times be kept before the student.

It was easier in old times to be a noted engineer, when the number engaged in the business was small, than at present, when the profession is large. We have now to supply a great body of engineers. The work of the school is to give a good education to the average student. The masters in the profession will still be few and far between, and either with or without the aid of the school will take the prominent places. We must expect now and then to see a genius arise superior to all schools, who sets all educational theories at defiance, and strides out far in advance of the best graduates. Teach as we may, Nature will continue to do as she always has—graduate her favorite pupils in her own manner.

In deciding just what to teach in the engineering school we must remember that we cannot teach everything in four years. We should devote that time to the more elementary things and to the more important things, while the more advanced but less essential things should be made the subjects for a post-graduate course. In the latter might come the higher mechanics, the higher surveying, geodesy, practical astronomy, experimental physics, and the like, for such students as have a taste for these things. In this part of the course, too, the individual tastes of the student may be allowed a certain degree of control in the selection of studies, which is not practicable, even if desirable, in the more elementary part of the course. I regard this as a solution of many difficulties which have developed under our present system of instruction, which seems to me defective in attempting to crowd too much and too difficult work into a four years' course for a class of students quite young and quite unused to higher technical studies.

In carrying out our course of training for the young engineer, we are never to lose sight of the fact that we are not only to teach our students to be engineers, but also to be men. The civil engineer has a connection with the public welfare that no other professional man has. Quackery is more fatal in this than in any other business. The hundreds of millions of passengers that annually travel over our railroads place their lives in the hands of the engineer. He is bound to provide for their safety. It is his privilege and his duty to do so. In the words of England's greatest engineer, "A man's ability is a debt he owes to the welfare of his fellow men." In all his labor the engineer should make self subordinate to the general good. It is not the business of an engineer to erect monuments to himself with his employer's money. That money is given to him in trust, and to waste it to gratify his own pride is violating that trust. To do the required work in a proper manner for the least money is what is required of the engineer. The student cannot too carefully study the lives of the older engineers, Smeaton and Brindley, and Rennie and Telford, and the Stephensons, in England; Gauthey, Navier, Perronet, and Rondelet, in France; and Bryant and Baldwin, Jervis and Child, Knight and Latrobe, Geddes and Wright, McNeil and Whistler, and a host of others in this country. Let him carefully study the lives, the character, and the works of these men, and above all, let him take to heart these words of one of the foremost living members of the profession, a man of whom American engineers are justly proud: "What should be our highest aim as engineers? Should it be to stand at the head of the profession, or to scrupulously discharge the duties of the positions in which we are placed? If the former, then we have many chances of failure to one of success, which will so often depend upon circumstances entirely beyond our control. If the latter, then success depends upon ourselves, for it is assured by simple and constant attention to the requirements of each occasion as it arises." Engineering is no less a business than a science, and the most successful engineer will be as much a business man as a scientific man. Our roads and railroads, our locks and canals, our bridges and tunnels, our sanitary and hydraulic works throughout the country, have been the result of very simple science, but of a great deal of practical skill and of good sound business talent. As a science, engineering is a very simple one; as a business it is often exceedingly complex. To train our young engineers so that they may produce the greatest useful result with the least expenditure of money, it must be kept in mind that to a thorough knowledge of the more elementary science must be added the most careful and faithful attention to the practical details of engineering business.

ON THE BALANCING OF MACHINERY.

DEDUCED FROM EXPERIMENTS BY THE DEFIANCE MACHINE WORKS, DEFIANCE, OHIO.*

INTRODUCTORY.

A ROTATING body, upon a fixed axis and not balanced, will cause a jarring by the solicitation of its heavier parts, by force of gravity, toward the mechanical center upon which it is compelled to rotate. The vibrations or jarring, caused by the unbalanced rotating parts of the machinery, are owing, not to centrifugal force, but to a striving, as of all rotating bodies, to assume rotations upon their centers of gravity. If it be desired that a rotating body run smoothly, without jarring its surroundings, its qualities must be the same as those of a body rotating in space, having a mechanical center upon which it is desired it shall rotate, and a mechanical plane in which it is desired it shall continue. Its mechanical center must coincide with its center of gravity, or it will leave its mechanical center, upon which it may be supposed to have been set in rotation, and assume a center nearer to the superabundant weight, by which its equilibrium is destroyed.

If a rotating body be so suspended as to be free to obey all impulses, except the attraction of superior bodies, the plane of rotation being perpendicular to the line of the earth's attraction, the point of greatest prominence will be somewhat in advance—in the line of direction of rotation—

* From a pamphlet issued by the Defiance Machine Works. The apparatus illustrated is the invention of Mr. C. F. Seymour.

of the point of greatest deficiency of weight. The amount of advance will vary, with variations of speed, through a range of about 35 degrees. An effort to constrain the body to rotate upon its mechanical center will very much increase such advance. Therefore, in any method of balancing the rotating parts of machinery, there should be, as nearly as possible, an absence of restraint.

The rotating parts of machinery whose journals are confined by rigid boxes furnish very conflicting indications of the whereabouts or the cause of unbalanced conditions. If boxes are constructed so as to be free to move in some directions and not in all directions, as they have been by some experimenters, the indications will be still more conflicting. The amount of "throw" caused by an unbalanced part of

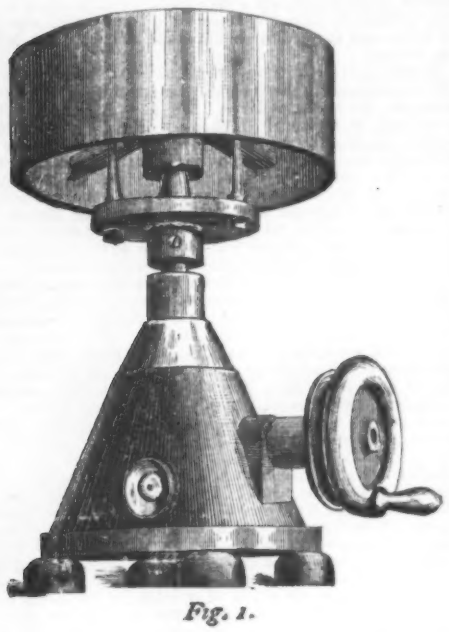


Fig. 1.

machinery is generally very small, notwithstanding the violence of its energy. There are stationary parts in the construction of nearly every machine, which are capable of vibrating in unison with the times of rotation of some running unbalanced part, and which are also capable of serving as accumulators of vibrations. Accumulations thus arising may be, mathematically, multiples of the times of the vibrations of other and heavier parts; and it is obvious that a violent shaking may ensue, even when the initial vibration is so small as to be almost inappreciable. The aggregation thus subjected to vibration will have a natural, isochronal movement, the periods of which will depend on its inertia, distance from its natural center of motion, and tendency to oscillate upon such center. When the periods of semi-rotation and the periods of natural vibration coincide, a continuous, but not always uniform, oscillation will be established. Upon the establishment of such oscillation, the time of rotation will have become slower, and the time of

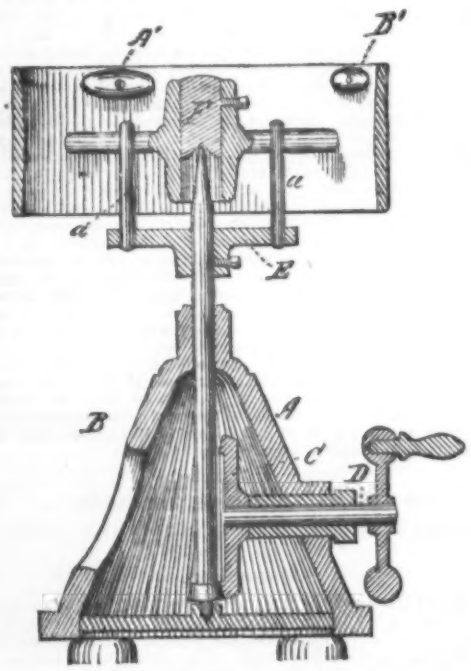


Fig. 2.

oscillation faster. That portion of the rotating body which possesses the excess of weight will, during its semi-rotation, strive to move in directions opposite to those of the vibrating mass, and, if it were not for the time which necessarily elapses in the transmission of force from the rotating body to the vibrating mass, the movements would be diametrically opposite. The conditions depending on dimensions, weights, times, and structure are so varied and complex that the relative times of the movements can only be determined by experiment in each individual case.

These "relative times of movements" often perplex the locomotive engineer, and lead him to think that the counter balances in the driving wheels of his engine should be augmented in weight, when they are already too heavy. Such counter-balances are more frequently too heavy than too light. Fig. 5 represents a wheel containing a counter-balance of double the weight it should be. Often, by watching intently the conduct of the driving wheels of his engine, he discovers that the light portion of the wheel strikes the rail violently, thereby transmitting a jar to the engine. Keen perceptions by sight, feeling, and hearing are necessary to the conclusion that the times of the contact of the light portion of the wheel with the rail and the times of the jar are simultaneous, or nearly so. He accomplishes the first offices of a good observer, and elate with that success, and having in mind the one property of the counter-balance, that of its centrifugal force, he fancies that an increase of its weight would hold the wheel to its proper place. By attention to Maxim E, such an errror can be avoided.

SYSTEM OF BALANCING.

A brief allusion to the old methods of balancing by straight edges, with its burden of fallacies, is all that is needed to show its inadequacy. Thin disks, or wheels like Fig. 4, may be brought approximately to a balanced condition by means of the straight edge test, but it is a tantalizing approximation, and leaves us utterly helpless with high speeds; while in treating objects like Figs. 6 and 8, the straight edges are not only useless, but are as likely to contribute to error as to truth. No man would be rash enough to at-

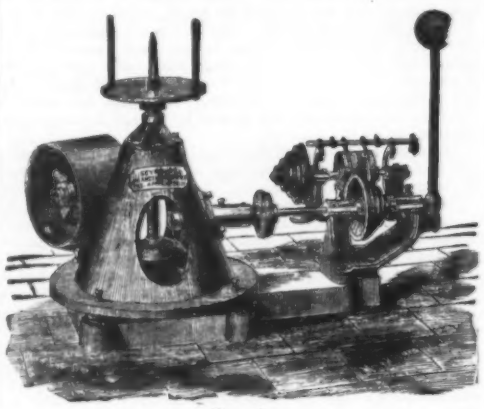
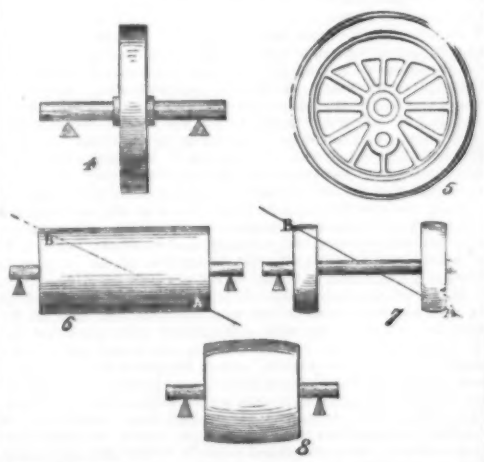


Fig. 3.

tempt to balance two pulleys at once upon a shaft, as represented by Fig. 7, from fear of getting an excess of weight, in such relative positions as are shown by B and A. Yet there are many mechanics who will not hesitate to try to balance a drum such as is represented by Fig. 6, and comfort themselves with the assumption that, if they have not done the best to be desired, they have done the best they can.

Figs. 1 and 2 represent a small experimental model, but which is large enough to balance objects weighing twenty pounds. A, is the case of the machine; B, steel spindle; C, frictional gear; F, plug in the hole of pulley; A, and B, balance weights in rim of pulley in process of balancing. Fig. 3 represents a large machine suitable for balancing objects that weigh one pound or a thousand pounds. It is driven through the media of frictional gearing, frictional clutch, double counters, and tight and loose pulleys; so that when the object to be balanced has attained the desired speed, the disturbing influences of the motive power may be withdrawn.

In describing the method of balancing a pulley we will leave the reader to infer the reasons for various operations, believing them to be sufficiently obvious. We place the pulley to be balanced on the pivot of the spindle B, as seen in Figs. 1 and 2, and before rotating locate near the center of the rim a weight of about the size necessary to produce a standing balance; then rotate, and mark upon the edge of the rim with chalk or a pencil of moistened clay. If the mark occurs within one-fourth of the circumference of the pulley from the weight, raise the weight; if the mark occurs at more than one-fourth of the circumference of the pulley from the weight, depress the weight. If, by these steps, the edge of the rim is reached and the pulley still "runs out," increase the weight, and place a counter-



weight diametrically and transversely opposite, so that the relative positions of the two weights will be as are those of B and A, in Figs. 7 and 8. Care must be taken at every adjustment of weights that a standing balance be not violated. If, upon the readjustment of the first weight, the mark occurs at one-fourth of the circumference of the pulley from the weight, nothing more can be done with such weight, but an additional weight must be placed at the mark, and if this second weight disturbs the standing balance, locate a counter-weight, as in the first described condition.

ANOTHER PLAN OF OPERATION.

When, upon the first rotation of the pulley—after locating a weight sufficient for a standing balance—the mark does not occur immediately above the weight, or directly opposite, two weights, the sum of which is greater than the one, may be substituted for the one, placed so that they revolve in different paths and are the proper distance apart, in the circumference of the pulley, to secure a standing balance. Then manipulate one or both of the weights according to their respective governance of the pulley, as implied by the first plan of operation. Theoretically, no more than two weights are required; but pulley-arms or other interfering objects sometimes make it necessary to divide the weights.

In balancing objects in which the center of magnitude is inaccessible by the pivot of the balancing machine, such as, for instance, a planer cylinder or thrashing machine cylinder, an entirely different method is necessary. A planer cylinder will sufficiently illustrate all cases. Let it be suspended in gimbals, as shown in Fig. 9, and be driven by frictional contact with the face-plate of the pulley balancer, or by other means. A small portion of its length should project above the gimbal pivots, G G. Bring the frictional gear, H, in contact with the face-plate by a steady bearing of the hand on the cross-head, I, until a sufficient speed of the cylinder is attained to throw its maximum amount; then bear it slowly away from the face plate, and mark

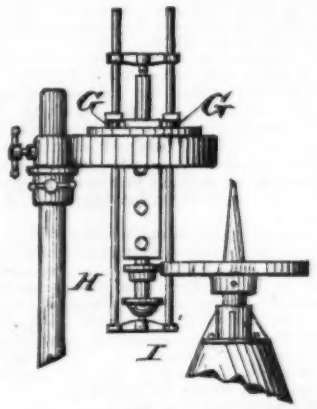


Fig. 9.

with a pencil of moistened clay or chalk upon the lower journal or other concentric part. The mark will always be found on the light side. The correction, either by cutting away the opposite side or by counter-weighting the light side, should be made at or near the lower end of the cylinder. When one end is thus corrected, the cylinder is reversed and the other end treated in like manner. It will be observed that, by this process, but one end of the cylinder is treated at a time; and that the corrections are applied to the ends only for the entire mass of the object to be balanced. Two or three reversals of the cylinder in the gimbals may be necessary if the upper end jar so much as to render the indications conflicting.

Fig. 10 represents a proportional scale for balancing moulding knives, planer knives, revolving cutters of whatever shape, knife capscrews, etc. To explain the reasons

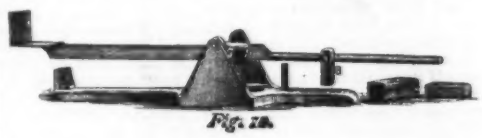


Fig. 10.

for its use, let A A, Fig. 11, represent two knives which are to be fastened on to the cutter-head, C. Let it be supposed that the knives are of the same specific weight, but that there is an excess of weight at the opposite ends, B B; then when revolving on the head, they will cause a violent jarring or "throwing," by reason of the excess at B', and at BB'. The knives could be reduced to the same specific weight by the aid of common grocer's scales, but that would not attain the object. By the use of the proportional scale the position as well as the amount of excess of weight can be ascertained; so that in reducing the knives to the same specific weight they may be made to agree in their corresponding parts. The method hitherto used is by reducing pairs or sets of knives to the same dimensions, and by aid of common scales to the same specific weight; but so great are the differences in the density of the parts of even the same knife that a still running set of knives is but an accidental result.

MANIPULATION OF THE PROPORTIONAL SCALE.

Let it be supposed that two or more knives are intended

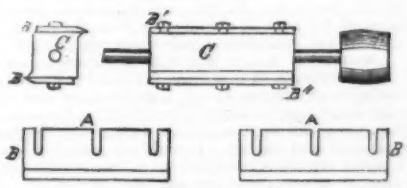


Fig. 11.

to be fastened on to one cutter-head, rotating at a high velocity; and that it be conceded that they must not only be of the same specific weight, but must agree in their corresponding parts. Place each knife in succession on the platform of the scales with its face toward the end-board, A, with a suitable weight at the opposite end of the beam. If by this test they all appear to be of the same specific weight, place them each in succession again, with their backs against the end-board, A. They may still appear to be of the same specific weight. Then place them each in succession flatwise on the platform, in as many different positions as of which they are susceptible, noting and reducing by an indefinite number of trials, the edges which are found to be of excessive weight, until they all are reduced to the same weight in their corresponding parts.

They will also then, of course, be of the same specific weight.

The balance weights, B B, are made oblong, so that by putting the heavy end up, the entire mass, consisting of weight beam, and knife, may be poised near its center of gravity, and thereby oscillate more sensitively. If, however, the objects to be balanced be very heavy, the weight must hang down, or the upper portion of the mass may preponderate. It will be seen that the operator can make the poise more or less delicate, according to the varied positions of the knives to be balanced.

Fig. 14 represents all the apparatus used in our system of balancing. The counters for the large balancing machine, J, have tight and loose pulleys 7 inches in diameter by 2¼ inches face, and should make 1,000 revolutions per minute. Thus the highest speed of the upright spindle will be 4,000 turns per minute; and the speed of planer cylinders in the gimbals, K, may be made to attain 10,000 turns if desired. N is a stand supporting bowls to contain chalk, clay, and water, and a rest for the support of the hand while marking the rotating object. In making examinations of the standing balance preparatory to rotating, set the hand rest under or near the edge of the object to be balanced, and rotate the object by hand, taking hold of the face-plate or other convenient hold and turning so slowly that the friction of the pivot will be sufficient to impel the object. L is the small machine on an iron table, constructed so that it can be driven from either one of the large machine

Fig. 12.

counters. M is the proportional scale for balancing knives, capscrews, washers, or other parts such as are fastened on to cutter-heads.

CAR WHEELS.

This system of balancing, in its application to car wheels, may be illustrated by Fig. 13, which represents a car wheel furnished with a series of holes, *a a*, which are conical in shape from their longitudinal center outward, and being so constructed that weights may be added to it near the periphery, in lines transversely to the plan of rotation. We will suppose that there is an excess of weight at *b c*. It is obvious that weights should be secured at *d e*, in order to prevent the violent lateral play to which wheels running at a high rate of speed are liable. The positions which these weights should occupy can only be ascertained by rotating the wheel to be balanced upon a pivot at a sufficiently high speed to cause the wheel to rotate in a plane parallel to its greatest sectional weight. While so running, the wheel can be marked by chalk or otherwise, according to directions given for balancing pulleys, and the prominences or marked portions will indicate the points of greatest deficiency of weight, and it is at such points that weights should be added in order to produce the true running balance of the wheel, and they must also be of the proper size to cause the wheel to rest on the pivot, when not rotating, in a horizontal plane. The wheel so balanced will, when put upon its axle, run at any rate of speed without jar or disturbance to any of its surroundings. Where both of the car wheels on an axle are out of balance, and their tendency to disturbance be in the same directions, a violent impingement of the flanges upon the rail is one of the most aggravating results. This, as well as all other causes of jar, can be eliminated. Our patents on balanced car wheels cover means by which all car wheels, of whatever construction, can be balanced.

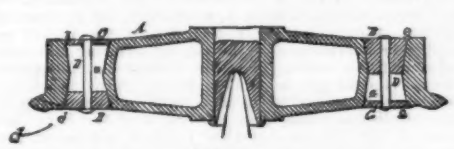


Fig. 13.

It will be seen that journals, supporting rotating parts of machinery, will be worn most on the sides presenting deficiency of weight. It is the light portion of a railway car wheel that pounds the rail and produces the jar which is a common cause of complaint. The properties of rolling bodies upon the earth's surface are subjects for pleasing investigation. Let a car wheel be considered in some of its phases. It cannot obey all the requirements of the law which governs rotating bodies, because of the constraint imposed by the rail, which forces the mass of which the wheel is composed out of its natural trajectory. Being constrained by the rail from obeying centripetal force, it exerts an energy downward proportional to such constraint, and hence the well recognized depression produced by rapid transit over bridges. All such depression, beyond what is due to weight, is dynamical, not statical, and is owing to the rapidly revolving wheels, their great weight much augmenting the dynamical effect. The depression produced by a railway train in rapid transit is not increased by the increase of the projectile force of the train, but is rather lessened; and if the projectile force were infinite, depression would be nil.

The increase of depression by increase of speed is therefore referable to the revolving parts only, and to the unbalancing of their central forces. It is owing to the violent unbalancing of these forces that a hoop or wheel stands erect while rolling upon the ground. The centrifugal force being free to exert itself in one direction only—upward—the point of contact on the ground being the center of motion, and centripetal force being constrained by the ground from adjusting the hoop to a rotation in space upon its center of gravity, the other factors, namely, the earth's attraction and centrifugal force, are left to phenomenally govern it.

MAXIMS.

In the course of extended and costly experiments, conclusions were reached which seem sufficiently stable to be regarded as laws. For convenience of reference, and for conciseness, we arrange them as such.

Maxim A.—If it be desired that a rotating body run smoothly, without jarring its surroundings, its properties must be the same as those of a body rotating in space, having a mechanical center around which it is desired it should rotate, and a mechanical plane in which it is desired it should continue.

Maxim B.—Its mechanical center must coincide with its center of gravity or it will leave its mechanical center upon which it is supposed to have been set in rotation, and assume a center nearer to the superabundant weight by which its equilibrium is destroyed.

Maxim C.—Every rotating body must be considered as having an axial dimension or line, measurable in a direction transversely to its plane of rotation. In order that it may rotate in a certain mechanical plane, relatively to its form, there must be an equal distribution of the product of weight multiplied by velocity in directions parallel to the plane of rotation, about every point in its axial line.

Maxim D.—If a rotating body have a corresponding distribution of the product of matter multiplied by velocity about all points in a circle described by its center of gyration, it will be in equilibrium when at rest—not rotating—upon its mechanical center. In other words, its mechanical center will coincide with its center of gravity. The center of percussion of a rotating body is that point at which it can oppose resistance, or strike an obstacle without communicating a shock to its axis. It coincides with its center of gyration.

Maxim E.—If there be within all parts of a circle described by the center of gyration of an unbalanced, rotating body, a sufficient amount of matter to resist by reaction the centrifugal tendency of an excessively heavy portion, such heavy portion will strive to recede from the mechanical center so long as the impelling force, applied at the mechanical center, continues and is opposed by inertia; but, when the inertia is overcome, the heavy portion will strive to approach the mechanical center.

Maxim F.—If the axial diameter of a rotating body exceed its equatorial diameter, and its plane of rotation be disturbed, it cannot recover its equilibrium within the first plane, but will strive to rotate in a new plane, parallel to its greatest sectional weight.

Maxim G.—In an unconstrained rotating body, the point of greatest prominence or point of greatest distance from the center of rotation is also the point of greatest deficiency of weight.

If some of the above maxims seem too obvious to be entitled to so formal a position as that which they occupy, it is owing to a desire to comprehend all the conditions and qualities of the rotating bodies with which mechanics have to deal. Mechanics, and even teachers of the laws of physics, too commonly drift into conclusions by a loose habit of thought, and entertain impressions which indicate an entire absence of observation. They are very persistent in holding to these impressions. A scientific (?) journal, in treating of wheels on shafts, states that "an unbalanced rotating disk will tend to bend or spring the shaft toward the heavy side." And again, swelling with the inspirations of mathematical formulæ, "An overweight of *w* pounds, describing a radius, *r*, with a velocity of *v* feet per second, will bring a strain upon the shaft *in the direction of overweight, etc.*" This erroneous notion prevails among mechanics. It is widely different from latter portions of Maxims B and E. By experiment we learn that in an unbalanced rotating body, the point of greatest prominence is the point of greatest deficiency of weight. The journals of shafts carrying unbalanced wheels or weights will wear most on their light sides, and not, as is too often supposed, on their heavy sides. All mechanics easily comprehend the fact that unconstrained rotating bodies rotate upon their centers of gravity, but too many of them lose sight of it in practice.

Millwrights and millers often lose their reckoning in balancing millstones, and in their perplexity leave a stone when they have succeeded in getting it to run in a plane parallel to its face, ignoring the fact that it is not in standing balance, or believing that they have done all that can be done. Such an adjustment of balance weights as is described in the rules for balancing a pulley would overcome all difficulties, and insure a true wearing of the parts by which a millstone is poised.

It has been demonstrated in a combination of three rotating bodies having individually and collectively a common center of gravity, like, for instance, a ring, B, Fig. 12, pivoted within a ring, A, and a wheel, C, pivoted upon its axis within the central ring, and the axis of each member or rotating body normal to the axis of its contiguous fellow member, that the outer and inner members will strive to maintain planes of rotation parallel to each other and in the same direction. If, however, the outer member be subjected to an oscillatory motion upon its axis, the inner member continuing to rotate, the intermediate member will be set in motion upon its axis, either in oscillation or complete rotation; for the inner member will strive at each movement of the outer member to establish itself in corresponding plane—as to parallelism—and direction of rotation. In thus striving, it will set the intermediate member in rotation, and if the times of oscillation of the outer member be suitable, the intermediate member will assume a complete rotation. All these conditions are realized in Bohnenberger's apparatus, and account for its phenomena.

Rotating bodies can be so poised that they do **not** oppose resistance to change of plane of rotation. A body may, without resistance, and in perfect equilibrium, rotate upon two axes, provided each axis be situated in the other's plane of rotation, and both rotations be around a common center of gravity. It is, therefore, erroneous to state, as is often done, that all rotating bodies oppose resistance to change of plane of rotation. The earth presents an example of rotation upon two axes by the oscillations of its plane of rotation, which cause the precession of the equinoxes. If those oscillations could be changed into complete rotations, all parts of the earth would be exposed in turn to the direct rays of the sun.

The oscillations in the plane of rotation of a boy's spinning top are analogous to those of the earth's plane of rotation. We say that the sun and the planets solicit the protuberant ring of the earth, and thus cause its oscillations. We ignore original impulse in the larger case; but how about the top and the character of the impulse by which its oscillations are established? The vertical oscillations of all terrestrial rotating bodies whose planes of rotation are horizontal, become more frequent as the speed of rotation decreases, until the times of natural vibration and the times of rotation accord or are reached and passed, after which they become slower. The oscillations of a body rotating at a very high rate of speed may be very slow; those of the earth being once in about twenty-one thousand years.

There was furnished in 1878, to the French Academy of Sciences, by a member, M. Gruey, an apparatus resembling somewhat that of Bohnenberger's. It may be described as a ring pivoted within a ring, and a wheel pivoted upon its axis within the central ring; and the axis of each member or rotating body normal to the axis of its contiguous fellow member. To the outer ring were imparted a series of oscillations, normal to the axis of the central ring. Interest was excited by the fact that so long as the rotations of the wheel were maintained, the oscillations would induce rotations of the central ring. No solution was offered. Indeed, any solution would be but a recapitulation of facts. In such an apparatus complete rotations of the outer member will insure such a voluntary adjustment of the inner ring as will render the plane of rotation of the outer member and that of the wheel coincident. Their directions of rotations will also coincide. They will thus remain in stable equilibrium. If, however, the gimbals are violently so set that the outer member and the wheel rotate in opposite directions, notwithstanding that their planes coincide, the slightest extraneous disturbance will cause the wheel to invert its axis and establish itself in a direction corresponding to that of another member.

There is a class of portable farm engines with a traction apparatus by which they are transported upon common roads. When an engine of that class is in transit, its balance wheel

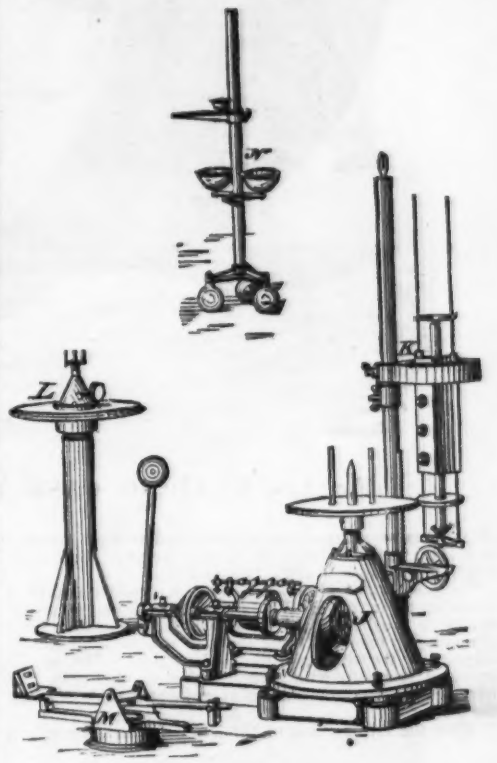


Fig. 14.

is in rapid rotation; and the persistency with which the wheel resists sudden changes of plane of rotation is noticeable as an agency by which the engine is preserved from severe jolts upon a rough road.

Acceleration of the rotations of a body may be produced by subjecting its supports to uniform vibrations. The first condition, in order to produce such acceleration of rotation, is that there must exist a certain relation between the times of rotation and the times of vibration. The second condition is that the center of gravity of the rotating body must not coincide with its mechanical center—in other words, the rotating body must be "out of balance."

Solution: The rotating body, in striving to assume rotations upon its center of gravity, will impart a vibratory motion to its supports; then when the extraneous vibratory motions are applied, and occur counter to the inherent vibrations, the resultant force is such as to push that portion of the rotating body having an excess of weight, out of its course; and it must, during the succeeding semi-revolution, fall back toward the center of gravity. In thus falling, it acquires additional velocity. The initial impulses of the extraneous vibrations are quite as likely to retard the rotations as to accelerate them; but if one extraneous impulse occurs exactly counter to an inherent vibration, and the latter slightly preponderate in force, there will ensue an acceleration of speed, and the succeeding inherent vibrations will just sufficiently lead the extraneous vibrations to insure a constantly accelerating rotation.

The above solution is applicable to all rotating bodies which are liable, by being out of balance, to vibratory influences.

Watchmakers have been known to apply a test involving this action, to balance wheels of watches, and throughout all the years of their employment have embraced an error in so doing. After balancing a wheel with the utmost care of which he was capable, a watchmaker has been known to place it in calipers by which it was supported by the pivots, draw the string of a bow across one of the arms of the calipers, and accelerate the rotations previously imparted to the wheel, imagining such increase of speed to be an evidence of a balanced condition. According to the solution above, the vibrations produced by the bow-string could not accelerate the rotations of a *balanced* wheel.

TOURIN'S MACHINE FOR PREPARING SADDLE LEATHER.

WHEN leather which is sold uncurried by the tanner is designed to be used for saddle and harness making, it is necessary, before working it up, to render it fit for the service to which it is designed, and to cause it to undergo a preliminary preparation in order to give it the requi-ite flexibility. The object of the machines shown in the accompanying figures is to perform such work mechanically.

The Treading Cask.—As the leather has to be soaked in tallow, it is necessary to give it a preparation in the treading cask (Fig. 1), that is to say, to open the pores of the skin to facilitate the entrance of the fatty matter.

The cask, which is of wood, is mounted by its axle on a double cast iron frame. This axle, which rests on two pillow blocks, is provided with a gear wheel corresponding to a pinion keyed upon the same shaft as the pulley, which is actuated by the shafting of the establishment. The cask is provided internally with three hundred wooden pins, 0·12 of a meter in length, and has an aperture at the side to admit the leather.

After the introduction of the latter, the cask is revolved at the rate of seventeen times per minute for half an hour; after which, it is removed and immersed in tubs filled with hot tallow.

This apparatus weighs about 1,500 kilogrammes, and requires a 1½ horse motive power. It holds eight sides of leather or ten backs, and is also used for treating soft leathers. In the latter case the operation is performed with water, instead of in the dry way.

The Cylindrical Treader.—The stuffing being finished, the leather is placed for half a day in a heating room having a temperature of 60° C., in order to cause the penetration of the tallow. When removed from this room the leather is very hard, and it is then allowed to soak for eighteen days in tubs filled with water.

To give it the flexibility necessary, it is finally passed through the apparatus shown in Fig. 2, which consists of two superposed cylinders, each provided with spiral series of pins. These helices run in opposite directions on the two cylinders. The lower cylinder is stationary, and is mounted upon a cast iron frame having at each extremity a gear wheel which is actuated by a pinion and two winches. The upper cylinder is free, and its axle is mounted on two bearings sliding in vertical slots, and against which constantly bear two elliptic springs, the tension of which is regulated by hand wheels.

After uniting two sides of leather head to tail, they are passed through the machine, and their free extremities are attached to each other. After this, the apparatus is maneuvered for about half an hour. By the constant action of the pins upon the leather, the latter is given a high degree of flexibility.

This machine weighs about one ton, and may be maneuvered by two men, or by belting driven by machinery.—*Annales Industrielles.*

FIG. 1.—TREADING CASK FOR STUFFING LEATHER.

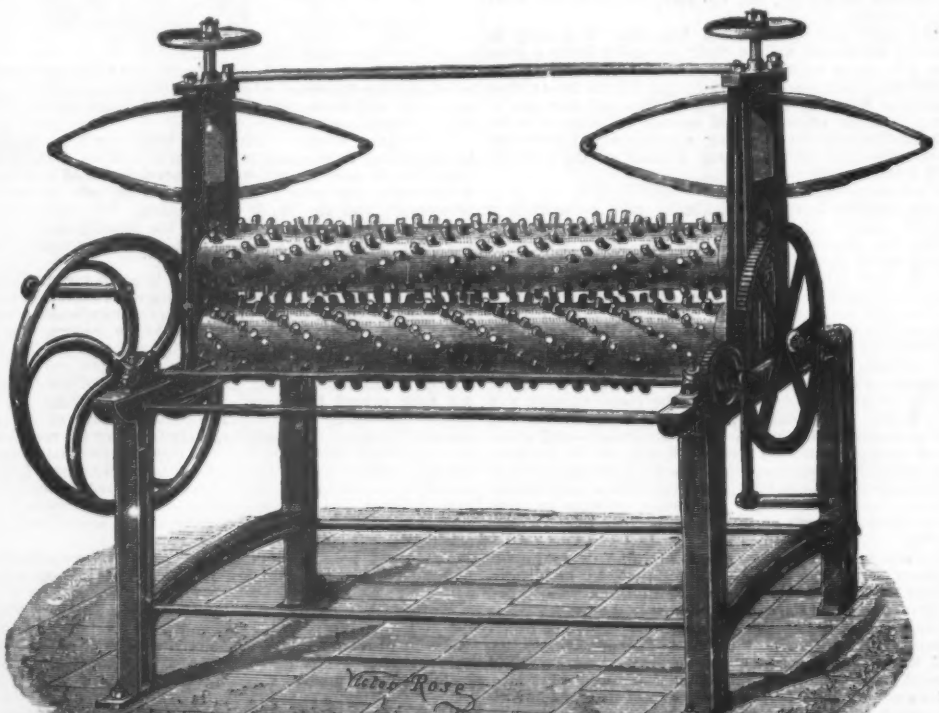


FIG. 2.—MACHINE FOR CHAWING LEATHER

THE ROYAL COURTS OF JUSTICE.

THE grand new Gothic building at the Temple Bar end of the Strand was first styled "the Royal Palace of Justice," in the Act of Parliament for its erection; but just as "the Palace of Westminster" is commonly called "the Houses of Parliament," we may expect that the ordinary designation of this magnificent pile will be either "the Royal Courts of Justice," or popularly, "the New Law Courts." They are to supersede, henceforth, for the use of the English Judicature, which now bears the collective title of "the High Court of Justice," all the buildings adjoining Westminster Hall, those at Lincoln's Inn, and those annexed to Guildhall in the City, which have been occupied hitherto by the several Divisions of Common Law and Equity Jurisdiction.

The locality of the New Law Courts is still in the City of Westminster; the ancient and glorious name of which is venerably associated, by past centuries of national history, as well with the chief administration of Law and Justice as with that of Government and Legislation for this realm. An area of seven acres, bounded south by the Strand; north by Carey street, Lincoln's Inn Fields; east by Bell yard, at Temple Bar; and west by Clement's Inn, and by the remaining part of Clement's Inn lane to Clare Market (which must soon be cleared away), comprises the space now occupied by the precincts of the Judiciary Palace. The buildings themselves cover, in the aggregate, not less than five acres of ground.

The design of the late eminent architect, Mr. George Edmund Street, R.A., was selected from others shown in competition, in 1872, when we published a view of the proposed Strand front elevation. Several years were spent in clearing the site, which was previously covered with a labyrinth of wretched courts and alleys, some sketches of which, and some notices of their historical antiquities—especially their associations with the haunts of notable English men of letters in the time of the *Tatler* and *Spectator*—appeared in this journal. The contract for the new buildings was taken by Messrs. Joseph Bull & Sons, of Southampton, for £700,000, which did not, of course, include the work of clearing the site. The contract was signed in February, 1874.

Since the death of the late Mr. Street, R.A., on December 18, 1881, his son, Mr. Arthur Street, has acted as the architect, in conjunction with Mr. Arthur Blomfield The chief clerk of the works, till his death at midsummer, 1878, was the late Mr. A. W. Colling, who assisted in preparing the whole of the contract drawings, 249 in number. Since his death the joint clerks of the works have been Mr. Samuel Wallace and Mr. Edward Moore; the latter has been engaged there since the building commenced, and has, in addition to being a general clerk of the works, superintended the warming and ventilating arrangements.

The Strand front, and the west elevation, are constructed wholly of Portland stone; so is the main Carey street front; but the east side, overlooking Bell yard, is of fine red brickwork, richly and prodigally relieved with stone. The interior sides of the quadrangle between the separate ranges of building is also of red-faced brick. All the bricks used were made by the contractors, at Southampton, to the architect's order, of a special size and shape, 10 in. by 5 in. and 2 1-8 in. thick, working four courses of bricks to the foot. Thirty-five million bricks, and a million cubic feet of brown stone, are put together in these buildings. The patent selenite lime was used both for all the brickwork and for the internal plastering, except in the Judges' rooms and principal staircases, where Keen's cement was used. We now proceed to describe the exterior of the building generally, referring to the larger view. (See pp. 5871–74.)

The Strand front is a complex and elaborate architectural composition of manifold Gothic features, partaking of the ecclesiastical, the baronial, and the palatial characteristics, here of the Plantagenet, there of the Tudor or the Elizabethan period, as though it were intended to symbolize the different ages of English history, from the time of Magna Charta to the sixteenth century, which have witnessed successive phases in the development of the monarchy, the consolidation of legal authority, overruling the excesses of feudalism, vindicating the prerogative of the Crown, repressing the interference of the Papacy, assuring the independence of this realm. All this is what the thoughtful historical student can see in Mr. Street's most instructive and interesting design, which is a significant commentary, if stone walls can speak, upon the reigns of the Kings and Queens of England, and upon the political and social progress of the English nation, let us say, during the times so dramatically revived for us by Shakespeare's series of historical plays. From a still earlier date, from the thirteenth century onward, the stamps of the times of our Henries and Edwards, in their regal stateliness; with the great Earls, Dukes, Regents, and King-makers, warlike vassals; and with the great political prelates, who were also great lawyers and statesmen, the Bishops, Archbishops, and Cardinals who were Lord Chancellors (see the cathedral-like window); and with the King's Justices of different Courts, originally belonging to the Royal Household; and with the strong infusion of foreign Court influences, from France or Anjou, denoted by some of the forms of those baronial towers, by their conical roofs and their jutting circular turrets, may be seen in the mingled configuration of this new Palace of English Laws. We are content, in exchange for such a truthful record, to acknowledge that, from a purely artistic point of view, as the art critics declare, Mr. Street's composition has its faults; we confess their existence. The architectural effect in general is not nearly so fine as that of the Palace of Westminster, which is a pure idealization of the Tudor type, having no properly historical character. There are provincial townhalls and assize courts of the Gothic style which claim more grandeur and beauty than this new structure. But this one has a noble story to tell; and the story is forcibly and faithfully told, thereby constituting a worthy monument of national history, as studied and cherished by the present generation.

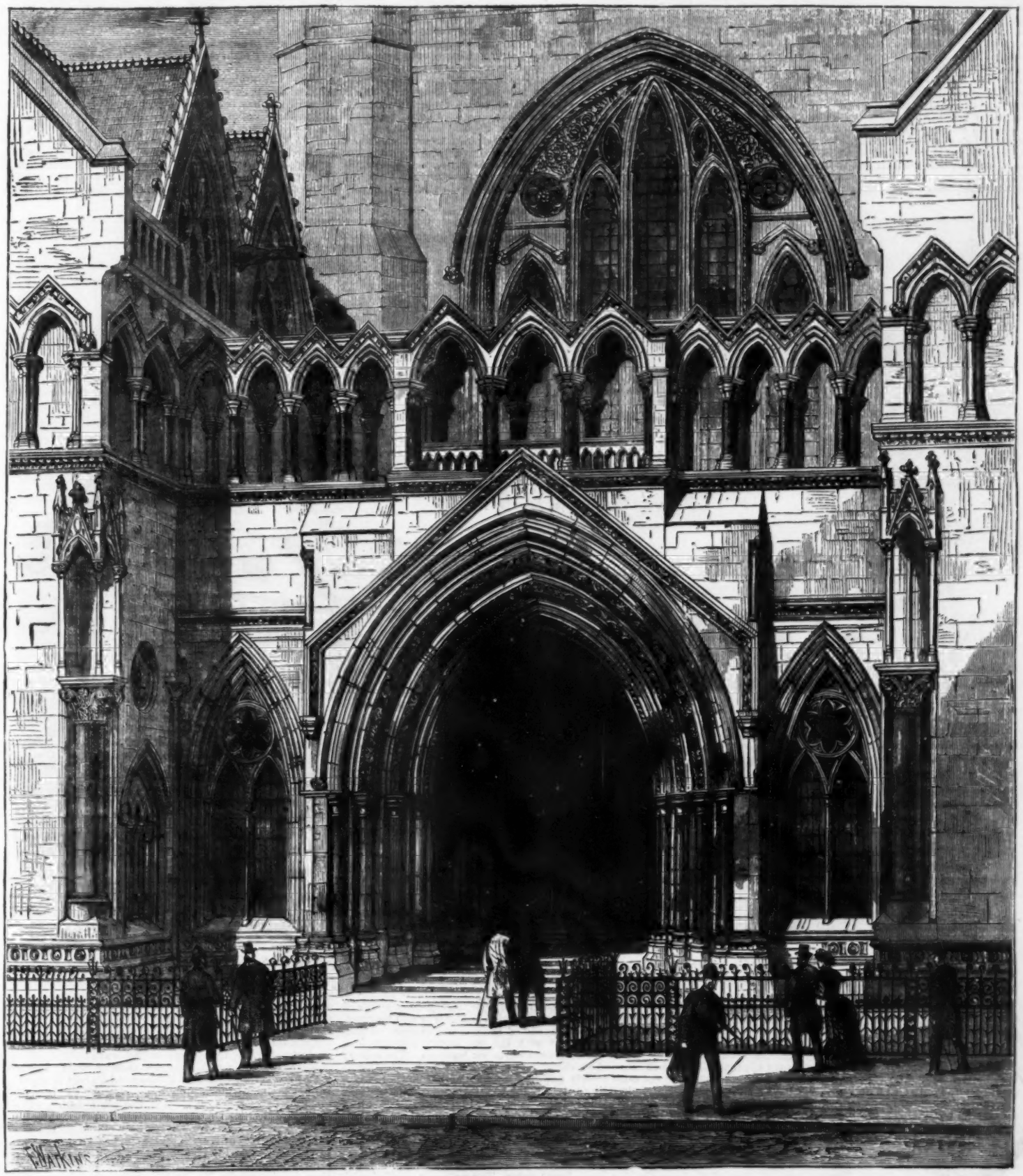
The north front, in Carey street, has a stately but agreeable appearance, showing more of the distribution of the main blocks of building, with regard to the accommodation of the different Courts and their offices. We consider the

central portion of the north front, opposite Serle street, to be really beautiful in itself; but the intelligibility of this entire front is a practical merit. The entrance on this side will be much frequented by professional men from their chambers in and about Lincoln's Inn. The west side, which has no public entrance, and which overlooks a plat of ground as yet only partially thrown open, presents an elevation of no well-defined plan or distinct character, but the part near the Strand has a pleasing effect. The east side, from Carey street, terminating with the clock tower at Temple Bar, has a bizarre singularity of aspect which provoked much remark when it first became visible, long before the other portions of the building rose to view. It

ing notice of the requirements of the different Courts, with the means of access to them, and the numerous subordinate offices and chambers for different classes of persons connected with these Courts. The eastern block or wing, on the Carey street side, is not the principal seat of any Court or judicial tribunal but consists entirely of chambers for officers of the Courts, Masters in Chancery, Chief Clerks, Registrars, Accountants, and a Branch Bank of England; with those to whom solicitors have to apply for all manner of legal formalities in the conduct of a suit at common law or equity, filing documents, sealing writs, entering an appearance, amending pleas, obtaining leave or order for this, that, and the other; even for procuring stamped paper.

Hall is of lead, constructed by Messrs. Dent & Hillier, and is 225 ft. high.

The whole Palace of Justice, now consisting of the eastern block and the main block, contains a grand Central Hall, nineteen halls for the Courts, and nearly 750 numbered rooms, of which some three hundred are in the east block. The corridors have a total length of nearly two miles. The Central Hall lies in the direction north and south, its upper end to the north, in the middle of the main building. The courts are situated mostly to the right and to the left of the Central Hall, seven on each side, besides two at each end. One of the Courts at the north end is larger than the others, being designed for a full Bench of the Judges sitting to



THE ROYAL COURTS OF JUSTICE.—THE PRINCIPAL ENTRANCE FROM THE STRAND.

may fairly be considered that the entire eastern block, with the great tower at Temple Bar, forms a different building; and the incongruity of its manifold intermixture of red brick with brown stone, in the striped and mottled face overlooking Bell yard, must not affect our judgment of the main edifice. There is plenty of variety in this vast and complex structure. The architect, it must be remembered, had to solve a most difficult problem in the arrangement of the interior, or rather the combination of several distinct interiors, with their respective systems of large and small apartments, passages, and staircases. A more arduous task has seldom been undertaken, and has seldom been more skillfully accomplished. This will be evident from an inspection of the interior, as now ready for occupation, tak-

These offices have been carried on in the new building for two years past, and the dark corridors and the convenient waiting rooms have been daily visited by hundreds of clerks of London solicitors, intent on such details of business, which neither the clients who pay their costs, nor anybody out of the profession, can possibly understand.

The south front, altogether, extends a length of 514 ft. along the Strand; the north front, in Carey street, has a length of just 500 ft.; the length of the east front, in Bell yard, is 480 ft. The southeast clock tower, at Temple Bar, rises to a height of 160 ft.; but the general height of the eastern block is 73 ft., not inclusive of the high sloping roof. The fleche or spire, above the roof of the Central

bear Appeal Cases. The Bar room facing Carey street has been fitted up as a temporary Court, making nineteen Courts in all.

The Central Hall, where her Majesty the Queen lately performed the opening ceremony, has an air of ecclesiastical solemnity, resembling the nave of a grand cathedral. It is not nearly so vast as Westminster Hall, but it is 230 feet long, 48 feet wide, and 80 feet high from the floor to the apex of the ceiling. The entrance to this hall from the Strand is by a beautiful Gothic arch, supported by columns of polished red and gray granite. This archway is adorned with fine carvings. The summit of the central gable, over this grand entrance, is adorned with a figure of Christ; on the gables to the right and left are the statues of King Solo-

mon and King Alfred. A broad flight of steps lead up to the level of the hall, 7 feet above the Strand. A lofty vestibule, with fine columns of polished marble, leads into the hall.

The floor within its partly of mosaic pavement, of variously colored stones laid in an elaborate design upon arches of Dennett's fireproof material; this floor has been executed by Messrs. Burke & Co., of Newman street. Along each side of the Hall is a series of nine bays, the floor of which is laid with Sicilian marble and dark lithograph stone, relieved with cross bands of buff colored lithograph stone. The side walls are divided by clustered slender shafts of colored granite. Four noble arches, with tympana, rise on each side, which are beautifully decorated with diverse carvings, all designed by Mr. Street and modeled in clay by his own hand. All the stone and wood carvings throughout the Palace were most skillfully executed by Mr. H. T. Margetson, of Chelsea, and many of them were modeled by him. The ribs of the groined ceiling are of Portland stone, filled in with Bath stone. At each end, north and south, the Hall is crossed by a transverse balcony, of polished Hopton Wood stone, the south one upheld very boldly, as it seems from below, on massive corbels resting upon columns of Purbeck marble. The arcade arches, on the east and west side, are similarly supported; the panels under these arches are formed with bands of polished Hopton Wood and Jura marble. The pillars of the north balcony are hexagonal, with twisted spiral volutes. The windows of the Hall are of Cathedral glass, slightly relieved with heraldic shields, in color, bearing the arms of most of the Lord Chancellors since the reign of William Rufus to the present day. This part of the work has been done by Mr. James Bell, of Great Russell street. Four broad staircases, of stone, lead up from the Central Hall to the level of the Courts, 25 ft. above the Strand.

The arrangement of separate ways of access to the Courts, for different classes of persons going thither, has been contrived with much ingenuity, and will be a great advantage to order and comfort. The staircases from the Central Hall, guarded by iron gates, each of which will have a janitor, are the witnesses' entrance to the several courts; the rooms for witnesses in waiting are level with the floor of the hall, separate rooms for male and female witnesses. From the waiting rooms witnesses go up by these stairs to the Courts. The jury approach the scene of their duties by quite different means of access. Two entrances, one on each side, in the middle of the hall, give the jurors access to four of the Courts. The others are reached by stairs at the ends of the hall. The rooms for the accommodation of jurors, which are neatly decorated with white and blue tiles, are situated beneath the Courts. Ingenious precautions are taken to prevent the jurors from finding it necessary to pass near the witnesses, lawyers, and parties. There are small spiral inner staircases for the attendants to run up and down. The public come in from the Strand on the south and Carey street on the north, by towers containing steps which lead to the public gallery in each Court without passing through the hall. Special entrances, stairs, and corridors, more or less handsome, are provided for solicitors, barristers, and the Judges. All the entrances from the hall are closed by iron gates. At its north end, and in like manner at the south end, the end gallery leads into a transverse corridor, where barristers can pass right or left to side corridors, thus going to any point all round the Central Hall. The total length of these barristers' corridors is 872 ft., on a level with the floor of all the Courts. This will enable a barrister to pass with great ease from one Court to another, to open a case in the first Court, to cross-examine a witness in a second, and then to conduct an argument before Lord Justices of Appeal in a third. The collection of the Chancery Division and Queen's Bench Courts so near together will doubtless do something toward assimilating the law and practice in these, as it will in some cases enable the same practitioners to appear in either. Beneath the barristers' corridor runs that of the solicitors, with ready means of communication between the two. The Judges have their separate passages, approached from their carriage entrances by grand oak staircases, and have only to cross a gallery reserved for them in order to pass from their private rooms to their own Court Rooms similarly situated behind the Bench are assigned to their registrars and other officers.

The Courts themselves, after all, must be of the greatest importance, for it is there, with the Judges on the Bench, that the work of dispensing Law and Justice will be finally performed. Ten of the Courts surrounding the Central Hall—namely, those at the south end and at the east side—are for the Common Law jurisdiction; six other Courts, of which three are situated on the west side, two at the north end, and one to the east, are for the Chancery or Equity business. The Admiralty Court, and that of Probate and Divorce, are on the west side. The average size of the Courts is about 38 ft. by 32 ft., but the Vice-Chancellor's Appeal Court measures 50 ft. by 43 ft. In some of the Courts about 40 spectators only will be able to find room; in the largest of them not more than 100 seats are provided; and, as in all cases the public will be kept from the ground floor, and there is a special entrance to their gallery, admission henceforth will be strictly regulated by the capacity of the accommodation: so that no crowds can interfere with the free ingress and egress of persons who come to the Courts on business. The gallery is well situated overhead, and facing the Bench. The Courts are not built closely adjacent to one another, but each is a separate building between the Central Hall on the one side and the outer shell of the Palace on the other. The outer shell is that in which the Judges' rooms and those of their officers are situate. The spaces for light and air between each Court are lined with glazed tiles. The interior of each Court is fitted with wainscot oak, some by Messrs. Jackson & Graham, some by Mr. Lovett, of Wolverhampton, and some by the general contractor. The walls are paneled with oak to the height of 14 ft. Some of the Courts are provided with jury boxes, and each of these has a special gallery just above the jury box, for jurors in waiting. Each Court has a public gallery of wood, each has commodious seats for the associates and for solicitors, as well as for the Bar. The seats for the counsel are contrived to fold up, and they have desks made to slide back. The Judges' seats are, of course, raised. In the Courts special places are assigned for shorthand writers, and great pains are taken to insure that they shall be within hearing of the witnesses. Each Court is provided with book shelves, which give promise of that indispensable aid to the administration of justice, a library. It is to be hoped that the acoustic qualities of the Courts are good. The distance of the bench from the bar is usually considerable, and the difficulty often felt at present by advocates in catching judicial utterances during the arguments ought to be diminished. There is an alcove of oak behind and above the bench, which may assist the voice. The Courts are lighted by windows, but in some cases from the top. The warming and ventilating arrangements will be found comfortable enough.

For the special accommodation of the Judges, there are four entrances to the Palace from outside; two in Carey street, one at the east side, and one at the west side. The ground on the west side is to be laid down with turf, and a few trees may be planted there. The Judges' carriage entrance will be on this side, whence a magnificent staircase, paneled in wainscot, will bring them directly to their own corridor. There are twenty-four Judges' Rooms, handsomely fitted up; the floors of wainscot oak, with a margin of mosaic pavement 18 inches wide all round. These rooms, and those of the Judges' clerks, have been furnished by Messrs. Gillow, and by Messrs. Collinson & Lock On the east side of the building there is another handsome entrance, with a marble staircase, for the Judges to come in; and on the north side, Carey street being at a much higher level, they have only sixteen steps to ascend. The barristers' entrance in Carey street has only eight steps leading to the level of the floor of the Courts.

Next to the Judges, indeed, the just consideration of the architect has been given to the convenience of barristers; and their dignity has been consulted in the style of apartments and passages designed for their exclusive use. The Bar Library, on the north side, is a fine room, 62 feet 6 inches long, and 32 feet 6 inches wide, the floor and ceiling of oak; it is reached by a staircase direct from the barristers' corridor, as well as their robing and retiring rooms, and their refreshment room. Small consultation rooms are provided adjoining the corridor, which has also convenient window-

THE ROYAL COURTS OF JUSTICE.—THE CAREY STREET FRONT.

Seats for less private conversation. There is another corridor, by which solicitors may get ready access to all the Courts.

Even the ground-plan of the entire Palace can hardly be made intelligible by a mere verbal explanation. It will, however, be understood that the eastern block, which was completed three years ago, is separated (except in the front) from the main block now completed by an intervening quadrangle, or inner open court, the north and south sides of this quadrangle being closed up by the continuity of the two fronts, respectively, in Carey street and in the Strand. But this feature of the general plan has long been obvious to every one passing through those parts of the New Law Courts' premises which were free to the public. We believe that, on the whole, Mr. Street's great work cannot fail to win the approval, in times to come, as well as among the contemporaries who lament his recent death, of all reasonable practical men competent to judge of the requirements of a public building. Its most serious practical defect is the sad want of daylight in the lower corridors of the eastern part, and likewise, perhaps, in some other parts which will now come into use. Borrowed light, from adjacent rooms to the right and to the left, is not sufficient for these corridors; and it is often difficult for persons meeting to recognize each other's faces. Where a host of solicitors and their clerks, and their clients, and the witnesses they will be trying to catch while the case is going on in Court, may be seeking one another, through this immense building, sometimes in desperate haste, the darkness of these passages will often be deplored. If some fault is to be found, therefore, with the allowance of natural light in the building, the supply of artificial warmth and the ventilation, it has been ob-

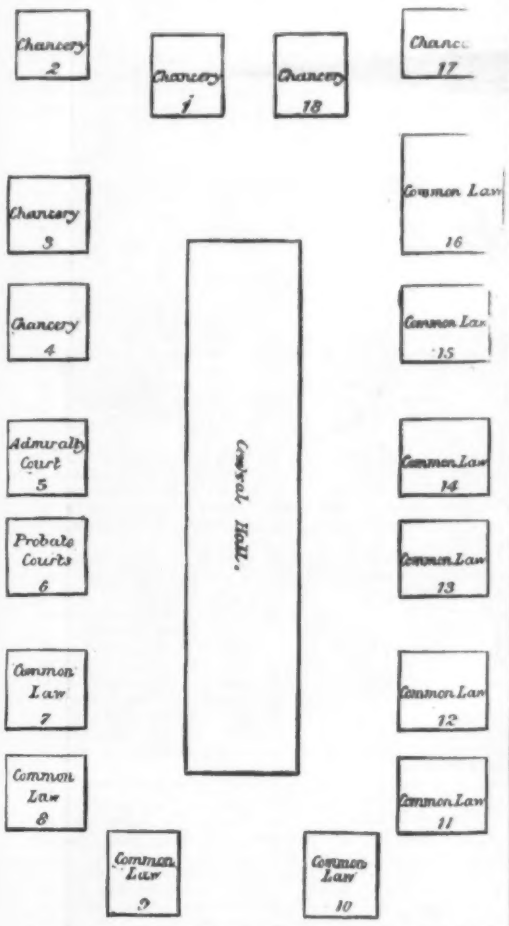
THE NEW ROYAL COURTS OF JUSTICE, LONDON.—THE STRAND FRONT.

served, merits our full approval. The machinery for these purposes is placed in the crypt beneath the Central Hall; there are six massive boilers, sending hot water through eleven miles of pipes into every part of the building; and there are coils of pipes for warming blasts of air driven through them by revolving fans into air chambers beneath each Court. Hot or cold currents may be admitted to these at discretion, and the temperature regulated with the greatest nicety. From these chambers the air, filtering through canvas screens, passes into the Courts above, being regulated by the officers of the Courts by means of valves under their own control. Ventilation is provided for by openings in the ceilings, leading the entire length of the building. It has been calculated that these arrangements will permit of the air of each Court being renewed four times every hour, or even more frequently if required. The heating of the Courts, however, is only one part of the work to be accomplished. They are to be kept comfortably cool in summer, and for this purpose the revolving fans already referred to will also be in requisition, with jets of cold water. The warming and ventilating apparatus was constructed by Messrs. Haden & Sons, of Manchester and Trowbridge, under the superintendence of Mr. E. Moore, Clerk of the Works. The Judges' Rooms and other retiring-rooms have ordinary open fire-places. The gas-fitting work, the wrought-iron gates, and other metal-work, has been done by Messrs. J. Potter & Sons, of Oxford; the lavatory and other such fittings, by Mr. Jennings, of Lambeth. The contract for the refreshment-rooms is taken by Messrs. Bertram & Roberts.

The Lord Chancellor has now the control of all the Courts. Mr. G. M. Hantler, the superintendent, is their responsible custodian. His staff should number not less than 120 men when the Courts are in full working order. The establishment of this staff is a piece of minor reform which will save public money. It will for the future do the work hitherto performed by the police, court-keepers, office-keepers, ushers, and messengers. The men wear a special uniform of blue with scarlet facings and neat distinctive caps. In course of time the familiar ushers, with their black gowns and wands, will disappear; as the present holders of the office drop out of the service their place will be filled by members of the new staff.

PLAN OF THE ROYAL COURTS OF JUSTICE.

We have explained the position of the Central Hall, with the surrounding Law Courts, eighteen of these being shown



PLAN OF THE COURTS AROUND THE CENTRAL HALL IN THE ROYAL COURTS OF JUSTICE.

in the annexed plan; the nineteenth Court for the present occupies a temporary place in the apartment designed for a barristers' robing room, in the northwest quarter of the building. It will be observed that the Queen's Bench Division, or Common Law, will occupy ten of the new Court-rooms, along the east side and south end of the Central Hall; while the Chancery Courts are at the northwest angle and at the north end of the Hall; the Appeal Courts lie northward, one of them, for the assembled full Bench of Common Law Judges, being the large apartment, No. 16. The Courts are so arranged that the upper end, with the Judges' Bench in each Court, is at the end farthest from the Central Hall; and the Judges' Corridor, which passes all around the upper ends of the Courts, will allow each Judge to pass into Court by a door fronting that of his own private room. The barristers' corridor, as elsewhere explained, passes by the other end of each of the Courts, next the Central Hall; while the solicitors, jurymen, witnesses, and spectators, or audience not engaged in the trial, have quite separate ways of access.—*Illustrated London News.*

NICKEL COINAGE.—Nickel is proposed in France as a substitute for bronze in coinage. To prevent it from being mistaken for silver the pieces will be octagonal, not round.

THE "FERRANTI" ALTERNATING CURRENT MACHINE.

IT is well known that Sir William Thomson's name was connected with that of Mr. Ferranti as a joint inventor of the machine, and we purpose, first of all, to give an extract from the former eminent electrician's patent, dated December 26, 1881, and numbered 5,668. After describing various forms of dynamo electric machines, the inventor goes on to say:

"Another form of dynamo is shown in part at Figs. 1 and 2. This consists of a wooden disk, A, with projecting wooden teeth, *t*, the whole mounted on an axle, B. A flat slip of copper or a square copper wire, C, bent round the teeth, *t*, to the form shown in the drawing, is fastened to the edge of the disk, A, in the manner hereinafter described, and having its two ends passing in toward the center of the disk to two suitably arranged contact-pieces. The fastening of the conductor, C, is effected as follows: a sufficient number of notches are cut across the edge of the disk, A, to receive the bends of the conductor, C. The conductor, C, being placed in position, wooden pins, D, are then laid in the notches over the conductor, the pins being of such a diameter as to project a little beyond the surface of each side of the disk, A. A stout steel wire, E, is then passed two or three times round the edge of the disk, A, on each side of the square wire, C, and so serves the purpose of pressing each wooden pin into its notch, in that way binding the conductor wire firmly to the edge of the disk, with strength enough to resist centrifugal force.

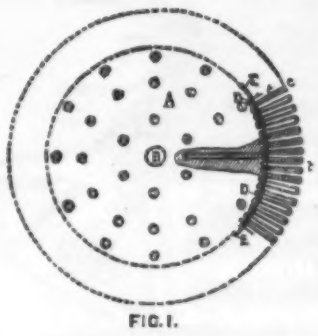


FIG. 1. FIG. 2.

"When greater electromotive force and less resistance are required, the zigzag may be made multiple of slip copper, as hereinafter described, with reference to the group of electro-magnets for this form of dynamo at Figs. 3 and 4.

"The hereinbefore mentioned form of dynamo, as represented at Figs. 1 and 2, is well adapted for an alternating current machine; the magnetic fields by which the radial portions of the moving conductor are excited being produced either by fixed steel magnets or by fixed electro-magnets, giving alternate areas of red and blue (true south and true north) magnetic polarity on the two sides of the space in which the radial bars move.

"When electro-magnets are used, I arrange them as shown in part at Figs. 3 and 4, so that each straight radial part of the conductor, W, serves to excite the soft iron of two contiguous electro-magnets, M, M.

"A flat circular cast-iron ring, K, is provided, having suitably shaped pieces of soft iron, M, M, bolted or screwed, as shown on its surface. A flat strip of sheet copper or a considerable number of mutually insulated flat strips are then bent, so as to pass round these soft iron blocks, M, M, in a zigzag manner, as shown in Figs. 3 and 4 (which is a transverse section of Fig. 1) and with the breadths of the strips, W, everywhere perpendicular to the surface of the ring, K. A sufficient number of such copper strips, W, insulated from each other, and from the iron blocks, M, M, and ring, K, and joined in series, form the exciting conductor. In this form of dynamo, a separate exciter must be used, and any convenient form of brush may be adopted."

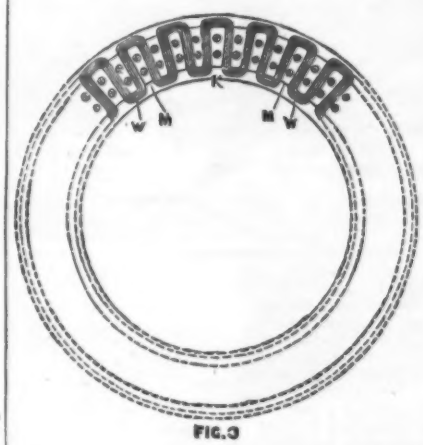


FIG. 3. FIG. 4.

From this illustrated extract, our readers will be able to judge for themselves as to what extent Mr. Ferranti has been forestalled by Sir William Thomson, so far as priority of invention is concerned.

Some of our contemporaries, when describing the Gordon alternating current machine recently, spoke of the use of a ribbon of copper in these terms:

"The use of a rod or ribbon for winding the coils instead of wire has recently been heard of a good deal. Mr. Gordon has experimented in this direction, and states that the effect of using a ribbon of such a width that the portion of its diameter which is furthest from the magnet poles is in a field of sensibly less intensity than the portion near to them, was, that only a very small electromotive force was produced at the ends of the ribbon, an enormous quantity of horse-power was absorbed, and in two or three minutes clouds of smoke poured out of the machine, owing to the burning of the insulator. The reason of this is easily understood by looking at the figures, which represent a ribbon or rod of copper passing between magnet poles, the direction of motion being supposed perpendicular to the plane of the paper. In Fig. A, the directions and lengths of the arrows represent respectively the directions and magnitudes of the electromotive force produced, while Fig. B shows the direction of the current due to them. Thus we see that only a small portion of the current arrives at the ends of the ribbon, and that most of it is wasted in forming 'eddies' in the width of the copper."

We are not quite sure of the precise width of the ribbon used by Mr. Gordon, but we believe, that when speaking with him on the subject, he mentioned three and a half inches. However, whatever it might have been, we could not conclude that the heating effect as described above was due to local "eddies," but rather to some short-circuiting or other cause overlooked at the time. Why Mr. Gordon chooses to employ a ribbon of such a width as to place its middle in such a position that it passed through a magnetic field of sensibly less intensity than did its outside edges, is a matter which we do not pretend to understand. One cannot help thinking, however, that these remarks were aimed at the construction of the machine we shall now describe. Fig. 5 is a general view of the "Ferranti" dynamo electric machine, and in a few words it may be described as being made up of a cast-iron frame in two pieces, each carrying 16 electro-magnets arranged in a circle, with their poles within a short distance of each other, and having between them a revolving zigzag shaped ring of copper ribbon composed of 12 layers. The two ends of this continuous ribbon are connected one to a ring attached direct to the axle supporting the armature, and the other to a second ring on the axle, but insulated from it. Two rubbers convey the alternating currents to two terminals, shown on the outside framework of the machine. The small pulley at the end of the axle is for the purpose of connecting the machine with a speed indicator. The electro-magnets are fed from a separate source, in this instance from a small Siemens machine of the D^6 type.

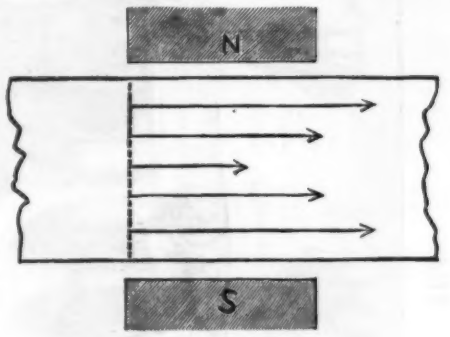


FIG. A.

The armature is partially shown in Fig. 6 as it appears with one side of the machine taken away. The length of the copper ribbon, which is wound continuously in a zigzag shape so as to produce 12 convolutions, is 120 feet. Its width is 12·5 mm., and thickness 2 mm, and its total weight 18 pounds. The convolutions are insulated one from the other by vulcanized fiber. The outside diameter of the armature is 21½ inches, and the mean diameter 15 inches. Its resistance is only 0·0265 ohm. From these figures our readers may calculate the mean, or periphery, speed of the armature, which, at the time of our first inspection of the machine, was running at 1,900 revolutions per minute.

We are not able to give the mechanical details of the manner in which the armature is attached to the axle of the machine, as we understand publication of this portion of the apparatus would endanger some of the foreign patents. Our readers of a mechanical turn of mind could, however, doubtless suggest many methods of accomplishing such an object, and we therefore fail to see the necessity for keeping back such details from the scientific press, whose endeavor is usually to present a *complete* description of any apparatus its representatives are invited to *publicly* inspect.

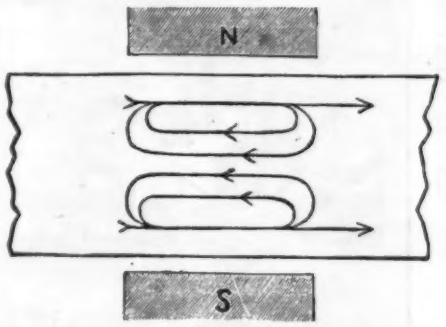


FIG. B.

The electro-magnets are alternately north and south, and their complete dimensions are as follows: length, about 6 inches; depth, about 4½ inches, and diameter at widest part, 3¼ inches.

The core of each magnet is wedge-shaped, with rounded ends.

The wire on each electro-magnet is 3·5 mm. in diameter, and consists of but four layers, weighing about 8½ lb., and the total resistance of all the 32 electro-magnets connected up in series is 2¼ ohms. The two lower terminals on the machine represent their ends.

The small Siemens machine used for exciting these electro-magnets produces in them a current of 21½ amperes. Their poles are within ¾ of an inch of each other, so that a very intense magnetic field is the result.

The height of the machine is 25 inches, and its base measures 24 × 23 inches. Mr. Ferranti informs us that its total weight is only 11¾ cwt.

This small and very compact apparatus, with the aid of the Siemens "exciter" (weighing about 2 cwt.), was producing the current which kept 300 Swan incandescent lamps in action at a *stated* luminosity of 20 candle-power each. The lamps were arranged between the main conductors—which, by the way, were naked copper wires of one-quarter

inch in thickness—three in series, so that an electromotive force of about 150 to 160 volts should be required for each set of three lamps, and a current strength of about 1·4 amperes. We are informed that in the absence of any but approximate measurements, the machine may be considered as having an electromotive force, or difference of potential between its terminals, of 125 volts.

It will be quite understood that these figures refer solely to this particular form of machine, as any difference in its construction may be made to produce higher or lower electromotive force, and, therefore, more or less current. According to the table of tests on Swan lamps which we published at the time of our description of Gordon's machine, a lamp of this kind, when at a luminosity of 20 candle-power, showed a difference of potential of 52 volts, and the current strength was 1·4 ampères. The resistance of each lamp would then be about 40, and three of them in series 120 ohms. One hundred sets of three would give an external resistance of 1·2 ohms, irrespective of the conductors. Therefore, this would show that either the electromotive force of the "Ferranti" machine as given to us is too low, or that the Swan lamps shown in connection with it do not give a light of 20 candle-power each; or again it may be that the lamps employed are of a different type to those used by Mr. Gordon.

But these are matters of little importance now, and can be put aside pending the results of trustworthy tests.

FIG. 5.—THE FERRANTI ELECTRIC MACHINE.

We are not aware that there is claimed for this machine much greater efficiency for horse-power expended than is obtained from certain other well-known types of dynamo electric machines, but the following advantages are set forth:

Its extreme simplicity, and therefore its non-liability to get out of order.

Its small size and light weight in comparison with other machines to do the same amount of work.

The trifling weight of the armature in comparison to the total weight of the machine.

The combination of a perfect mechanical and electrical construction and a high degree of electrical efficiency from the small weight of material employed.

The low price of the machine, considering the work accomplished.

While writing the above description of the machine, we received every assistance at the hands of Mr. Ferranti. A large number of gentlemen connected with the press, and others scientifically interested in electric lighting, lately met in the Cannon Street Station Arches, Cousen Lane, Dowgate Hill, for the purpose of publicly inspecting the "Ferranti" machine. The number of Swan lamps in circuit had been increased to a total of 320, and we were officially informed that they are of that type usually employed by Messrs. Siemens Bros. for their installations of the incandescence lamps, viz., lamps requiring a difference of potential of 41 volts, and a current strength of 1·28 amperes to

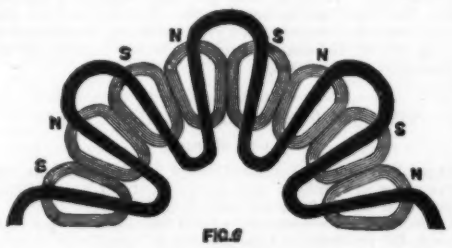


FIG. 6

produce a light equal to 18 standard candles. The machine was then said to be producing 160 amperes, with an electromotive force of 125 volts. A considerable difference of opinion seemed to exist among those present as to the candle power of the lamps, but as they were all strung so close together, it is quite impossible to give a fair estimate as to the amount of light produced, although we should be inclined to think that the luminosity was not nearly so high as that stated. We say this not merely from personal observation, but also from a comparison of the following figures given to us with those that have been deduced from many reliable tests The indicated horse-power of the engine—one of John Fowler's 16 horse-power nominal—when driving both dynamo electric machines in circuit with 300 lamps and including the interposition of countershafting, was said to be but 25·5, or, in other words, that 12 lamps of 20 candle-power are realized from each indicated horse-power. The engineer in charge of the "Ferranti" system informed us that the engine indicated *about* 7 horse-power when driving the countershafting and the machines free.

We leave our readers to make their own calculations and to decide for themselves whether the results said to be given by the "Ferranti" machine are correct.

Are the indications of the horse-power too low, or is the estimated candle-power of the lamps too high? As these are points which will be cleared up by reliable tests, we do not desire that our remarks should be looked upon as hostile to this latest development of dynamo electric machines. On the contrary, we are extremely pleased with the new machine, and only wish to draw attention to those points in which errors may most readily occur. Mechanical engineers are apparently disagreed as to the advisability or even practicability of constructing such a form of machine with a very large armature, owing to the difficulty which would probably be experienced in firmly securing the armature against the effects of centrifugal force, but we have sufficient confidence in the ability of our engineers to believe that no serious obstacle will arise in this respect.

The differences existing between the two latest dynamo-electric machines publicly exhibited is very striking.

The "Gordon" weighs, complete, 18 tons, its electro-magnets are excited by two "Bürgin" machines of considerable size, and it has been seen in operation with 1,300 Swan lamps in circuit of 20 (stated) candle-power each. It is constructed to actuate from 5,000 to 7,000 similar lamps with adequate driving power. The wheel of revolving electro-magnets weighs 7 tons, and its diameter is 8 feet 9 inches. The weight of wire on the machine is 5,376 lb.

Its speed at its maximum would be about 200 revolutions per minute, and it is coupled direct with the steam engine.

The "Ferranti" weighs, complete, 11¾ cwt. Its electro-magnets are excited by a small Siemens machine, weighing about 2 cwt., and it has been publicly shown in connection with 320 lamps of a similar character to those above.

The revolving armature is 25 inches in diameter at its extremities, and its weight is 18 lb.

The weight of wire on the machine is 290 lb.

Its speed is about 1,900 to 2,000 revolutions per minute, and it is driven by belting from a pulley.

From these figures interesting comparisons may be made as to the relative advantages possessed by the two machines, although the "Ferranti" is placed at a disadvantage by reason of its very smallness.

The advantages already enumerated are not, we think, exaggerated, and one of the great drawbacks hitherto existing, viz, the high prices of the machines, seems to be in a fair way of being reckoned among the things of the past. A point which must not be overlooked is the long time the armature can be kept running without any dangerous heating.

It is said that the machine we have here described might, with a trifling alteration, be made to give 500 lights, and a machine to give 2,000 lights, which is in course of construction, and which will be ready to be supplied at an early date, is only very slightly larger.

The large sizes which the company have in hand are said to be capable of yielding 1,000, 5,000, 10,000, and 25,000 lights respectively.—*Electrical Review.*

ON THE TRANSFORMATION OF STATIC ELECTRICITY INTO VOLTAIC CURRENTS.

A VOLTAIC current thrown into any given conductor determines by induction a counter current into a closed circuit which is adjacent and parallel. If we remove the inducing current, we obtain in the same circuit a current opposite in direction to the first. If the resistance of the induced current is great enough, the two currents thus produced take the character of tension electricity, and may reproduce the effects of ordinary electric machines. This is the theory of the Ruhmkorff coil.

It was therefore natural to ask if the system is not reversible; and if, in other words, on passing the discharge of an ordinary electric machine into the fine wire of a coil, we might not obtain in the thick wire an induced current of a very feeble tension and analogous to voltaic currents.

It was only in 1875 that Bichet made his first experiments. With a Holtz machine and a Ruhmkorff coil he was able to decompose water, and to deflect permanently the needles of a galvanometer. He stopped here, and whether he did not seize the full importance of his discovery, or that other more pressing researches drew off his attention, he did not occupy himself with them further. Professor Goir also sought to transform static electricity into a voltaic current. The announcement of the discovery of the French *savant* caused him to suspend his labors, but he resumed them when he saw that Bichet had laid the question aside.

For the success of the experiment the electrical discharges must be rather strong. Without this condition (which is easily realized by the aid of condensers) the effects of the induced current will be too feeble to be easily observed. Another condition is that the interval between the inducing sparks must not be too great, so that the current may not lose the quasi-continuity which approximates it to voltaic currents.

This current, further, has a character by which it can be readily distinguished. Instead of being truly single and continuous, it is double and discontinuous. When the spark passes into the thick wire, it determines an induced current in one direction, and, immediately after the passage of the spark, another current in the inverse direction, but the rapidity of the electric discharge is such that practically these two currents only form one. Another cause of discontinuity is the discontinuity of the inducing sparks. With the exception of these two characters, the current behaves in all respects like the currents produced by batteries with liquids.

Its tension is at first very feeble, since it does not give a spark, even on the slightest interruption of the circuit. If the current is put into the acidulated water of a voltameter, we obtain decomposition, and, under each receiver, we find a certain quantity of gas. As the current is continually inverted, the gas is a mixture of oxygen and hydrogen, the proportions of which vary in each experiment. Perhaps, by suitably regulating the resistance in the induced circuit, we might find the means of eliminating one of the two simultaneous currents, and of thus separating one or other of the gases. If a galvanometer is interposed in the circuit, the needle is not sensibly deflected so long as the circuit does not present a special resistance; but, if we interpolate an interrupter (*e. g.*, Froment's vibrating reed), the needle is suddenly deflected, and this deviation is considerable enough to give a hope of the possibility of utilizing the induced current.

If we cause one of the rheophores to communicate with a file and run the other over the teeth of the file, we have a train of reddish yellow light like that which we obtain on repeating the experiment with the wet battery. This phenomenon is not that of the spark. It is due to particles of iron and carbon which are detached from the file under the action of the current, become fused or volatilized, and establish thus a kind of bridge between the teeth of the file over which the rheophore is passed.

The two rheophores terminating in very fine carbon points prepared for the voltaic arc are brought in contact. On separating them carefully we see at once a jet of electric light analogous to that furnished by the Gramme machine or the batteries. On repeating the experiment with a conduction wire and a mercurial bath, we obtained a luminous arc due to the incandescence of the mercurial vapors. This arc is less bright, but more durable.

This induced current on circulating round a cylinder of soft iron produces rapid magnetizations in two opposite directions, which may be shown either by the magnetic spectra obtained with iron filings or by the vibrations of a very light and mobile plate of iron.

Lastly, the most curious experiment of all—the induced current produced in a Ruhmkorff coil by electric discharges may be directed into a second coil like the current of a battery, and determine long sparks with which all the phenomena of the Ruhmkorff coil may be repeated.

Thus the result is a transformation of static electricity into a dynamic current. If with the small Holtz machine which served him as a current-exciter, M. Goir has been able to decompose water, to ignite a bad conductor, and to produce the voltaic arc, we may hope by improving the apparatus to obtain powerful electric currents with the machines which produce static electricity, and that with a much less expenditure of force. Perhaps by multiplying, or better insulating, the discharges of atmospheric electricity, we may render ourselves masters of this agent, equally capricious and menacing, and turn it to domestic purposes.—*Les Mondes.*

HEAT.

To the Editor of the Scientific American:

The article "Heat" in "Chambers' Cyclopedia" (J. B. Lippincott, Philadelphia, 1875) contains the following:

"If a freezing mixture be placed at one focus of a spheroidal mirror and a thermometer at the other, the latter will fall speedily, though very far off from the mixture. Now, the real explanations of such phenomena are to be found in what is called the theory of exchanges (first enunciated by Prevost, and since verified and greatly extended by Stewart), which is to this effect: that every body is constantly radiating heat in all directions; the amount radiated being nearly proportional to its own temperature. Hence, the apparent radiation of cold in the above experiment is due to the fact of the thermometer radiating off more heat than it receives, as its temperature is higher than that of the freezing mixture to which it is opposed."

As this Cyclopedia and its reprints have had a very extensive circulation, it is desirable that so obvious an error be corrected.

In theorizing on this and kindred subjects, it is absolutely necessary to eliminate all preconceived ideas derived from physiological sensations. When we touch ice we say it is cold, and when we handle a pipe bowl in service we say it is hot; but, although these terms convey an idea, they are scientifically inaccurate, for ice possesses in fee simple no less than 491° Fah. of absolute temperature; the pipe bowl may stand on the same scale at 700° Fah.; but, if this is "hot," how shall we designate molten iron?

Our author admits that a "hot" body substituted for the ice will cause the thermometer to rise; now, a red hot iron ball is probably at 1,000° Fah., and causes a very rapid rise in the opposing thermometer. A ball at 900° Fah. acts less energetically than the one at 1,000°, and balls of the temperatures of 800°, 700°, 600°, 500°, all cause the thermometer to rise in exact proportion to their indicated temperatures. A blackened tin box filled with hot water likewise causes the thermometer to rise, and so we go down the scale until we arrive at a hot ball only exceeding the recorded temperature of the thermometer by a few degrees, and still, if our mirror be a good one, the thermometer still rises; but while our author admits these facts, he practically asserts that a body 20° or 30° colder (so to speak) than the thermometer ceases to radiate heat.

That such distinction is untenable will appear from the following, and the apparent paradox that a body radiating *heat* can cause a thermometer to fall be likewise explained.

It is approximately demonstrated that a body at —459° Fah. will be without molecular motion, in other words, cease to emit heat.

The lowest recorded temperature is about —220° Fah., although it is probable that with improved appliances this may be excelled; but, as above stated, it is almost certain that when —459° Fah. is reached, molecular inertia will ensue, and consequently manifestations of heat cease entirely.

Now, compared to this state of entire non-emission of heat, Natterer's mixture is comparatively warm, and solidified mercury at —39° Fah. is, in comparison with Natterer's mixture, not a very frigid body; again, ice at 32° Fah., compared to solid quicksilver, is quite warm; we now come in the ascending scale to wax, phosphorus, sodium, etc., frozen bodies in fact which are much warmer than the ice, and so on *ad infinitum*.

But it is true that, physiological impressions aside, we have not in this list, extending through a range of 375° Fah., a single body destitute of heat, and the very lowest in the scale, Natterer's mixture, possesses no less than 239° Fah. of absolute temperature.

Now, it is an axiom that all bodies radiate heat, properly speaking, but the difficulty of many in considering lies in the fact that a body radiating heat should cause the thermometer to fall, and yet such is the fact.

The emanations of heat from a block of ice produce the sensation known as cold, and yet they are genuine heat rays, and there are not wanting situations in which they are felt as decidedly warm!

Take for an illustration an Eskimo entering his "igloe" from an outside temperature of —70° Fah., who feels the radiations from the walls of his dwelling as sensibly warm! To further demonstrate their *heating* qualities, place a block of ice in the near focus of a spheroidal mirror, and a thermometer at the temperature of the room (in this case 20° Fah.) in the other, the thermometer will rise! I presume even our author will admit that in this case it rises by reason of receiving heat from the opposing ice reflected from the speculum, and originating in the ice. Now, that these same heat rays cause the thermometer to rise from 20° Fah. is a demonstration that they alone cause the thermometer to fall in the quoted experiment from the Cyclopedia.

Assuming the mirror in the original experiment to be 12 inches diameter, and its radius of curvature such that the heat emanating from a hot body 12 inches from its surface will be brought to a focus 60 inches distant, then the heat received from a heated ball in the near focus will exceed that received from the same ball in the farther focus in the proportion of 25 to 1; and if the hypothesis of the thermometer falling by reason of radiating its own heat has any foundation, it should fall much more rapidly if the freezing mixture and thermometer change places (supposing the speculum to be a factor of consequence in the experiment), for in

this latter case the mirror will receive and reflect from the thermometer twenty-five times as much heat as in the original experiment: but we find in fact that it falls *much slower*, and the reason is plain—the speculum receives only one-twenty-fifth of the rays from the ice which it did in the original experiment, and the thermometer receives proportionally less.

That the thermometer radiates heat which is converged by the mirror upon the ice or freezing mixture in its further focus, is quite true, but this in no degree accounts for its fall, for if we remove the mirror altogether and place the thermometer at the same distance (60 inches) from the ice, we find it to fall very slowly, but upon replacing the mirror it falls rapidly. Now, I presume no one will argue that a mirror has any power of drawing or attracting heat from the thermometer, and yet such supposition is necessary to account for the phenomenon of the original experiment, taken in connection with the change of position and its accompanying phenomena, and viewed from our author's standpoint. That it is not the case may be demonstrated by placing two hot bodies with thermometers attached in one room, before one of which is a concave mirror; they will lose their heat at precisely the same rate. This experiment, taken in connection with the preceding, effectually disposes of the theory of exchanges.

To finally sum up, heat is alone in its kingdom, pervades all bodies, and constantly restoring its equilibrium when disturbed by natural or artificial causes, produces the sensations popularly known as heat or cold; the latter being in all cases simply a less degree of the former, and *susceptible of radiation and reflection* until we reach the absolute zero, where such manifestations cease.

The following simple experiment will convince any one of the truth of the foregoing arguments. Place in the near focus of a large and accurate speculum a lighted candle, and note accurately the distinct point where a distinct image is produced; now substituting for the candle a block of ice, place the finger or back of the hand at the point where the image of the candle flame appeared; the instant sensation of cold produced will convince the most incredulous that there is a real convergence of the mirror heat rays from the ice, *cold* to our sense, but warm as regards a thermometer at 90° Fah., and if such be placed in the distant focus it will rise, showing unmistakably an accession of heat.

JAS. L. GORDON.

Boston, Mass.

CREOSOTE—ITS TESTS AND ACTION.*

By M. HAGER.

I HAVE previously written on the curative value of creosote and the preparation of creosote pills. Now that we are able to procure and dispense genuine creosote from beechwood tar, I take the liberty of again treating the subject from a therapeutical and chemical point of view.

Camboulives, a French physician, warns us in his *Manuel Pratique de la Therapeutique* to distinguish well between creosote and phenol (carbolic acid), as the former from beechwood tar was destined to play a great part in therapeutics, owing to its powerful action. More than this; it coagulates albumen, has the property of preserving animal substances for a long time, and being antiseptic, anatomical preparations can be kept in a lasting state of preservation.

But creosote has other virtues, owing to its causticity and astringent power. When put in contact with the skin, it produces wounds that are similar to burns, and pain like them. On account of its corrosive power it is much used to kill the tooth nerve in toothache. When diluted it is no longer caustic, but becomes astringent. Taken inwardly in moderate doses it develops a feeling of warmth in the stomach with sour eructations, etc. When it has passed into the blood circulation, it tightens the capillaries, and decreases the mucous flow both in the bladder and the air passages.

Camboulives remarks further: "This medicament has enjoyed an undeserved reputation since its discovery, for people were soon convinced that it was only useful for carious teeth and toothache." Nevertheless, Bouchard and Gimbert endeavored to restore its reputation as a curative agent, and they administered in pulmonary consumption, etc. Their experiments were successful, and they have published a long list of their observations, to the effect that creosote after being administered for a week or two has the effect of decreasing the expectoration, lessening the cough, increasing the appetite, removing the fever, increasing the strength, and almost suppressing night sweats, while it gives an *embonpoint* such as the patient had only in his healthy days. The abnormal noise heard in the breast of the consumptive ceases and is replaced by a healthy respiration, or at least is smoother in sound, owing to the cicatrization of the diseased pulmonary tissue. The improvement in condition may continue for months, provided that the cure is not interrupted too soon. These physicians observed that the symptoms of the disease recur as soon as the use of the creosote is neglected in the opinion that the lungs are healed.

From these statements it will be seen that Camboulives and many others did not believe in this beneficent action of creosote. They used it without obtaining the desired results. But creosote is a medicament that comes into the market of various degrees of quality, and if the apothecary does not dispense the genuine beechwood tar creosote—*Kreosotum faginum*—the expected results cannot be had.

To ascertain how justified was this unequaled action of creosote, I made use of it in several cases, and I found that consumptives and sufferers from chronic catarrh visibly improved, and in one instance its use had to be stopped because the *embonpoint* of the patient, who had lost flesh considerably, had so increased that new and large clothes had to be obtained. The results obtained by Bouchard and Gimbert have been fully confirmed by my experience, but, of course, only where genuine creosote is employed.

Among the curative qualities of creosote must also be reckoned its anti asthmatic action. A railway employe who suffered from *asthma spasticum*, and who derived some relief from the usual remedies without getting rid of the attacks, had only two attacks after taking the creosote pills. These, however, were mild, and they then ceased altogether. As a precautionary measure, however, he continues to take the pills every other day.

As creosote made from beech tar is one of the grandest remedies for keeping up consumptives and those suffering from bronchial diseases, for increasing the flesh of the emaciated, removing asthma, and perhaps bringing tuberculosis to a standstill in its early stages, as well as relieving kidney diseases and destroying the vitality of intestinal worms, it is the incumbent duty of the apothecary to dispense only the genuine and to convince himself of its quality. We shall explain the marks of genuine creosote and the sources from which it can be had.

In a case before me are phenols and creosotes, as follows:

1. Colorless Kreosotum.
2. Colorless Kreosotum album verum.
3. Yellow Kreosotum Anglicum.
4. Brownish Yellow Kreosotum Faginum.
5. Chemically pure Ph. G. Kreosotum from beechwood tar (Kreosot Hannoveranum) yellowish.
6. Kreosotum Saginum (A) yellow.
7. " " (B) yellow.
8. " " (C) brown.

Out of these eight kinds only Nos. 4 and 5 proved to be genuine; No. 8 was genuine, but very dirty.

1. Pure creosote made from beechwood tar is insoluble in double its volume of anhydrous glycerine, while other creosotes are completely soluble, or give a perfectly limpid mixture. When the mixture is milky, or whitish, with double the volume of anhydrous glycerine, the creosote is presumably pure, but if colored (No. 8 was of a muddy red), then the creosote is not genuine.

Phenol is not an adulterating agent in every case; there are others which are not soluble in glycerine, and least of all in a solution of 75 per cent. of glycerine (as for instance creosol or creosylalcohol).

Nos. 1, 2, 3, 6, and 7, when mixed with a double volume of anhydrous glycerine, gave clear liquids. Mixtures of 1/4 to 1/5 of creosote and 3/4 to 2/5 of phenol with glycerine under the same conditions give clear liquids.

2. To observe the action of the phenol, we mix three volumes of glycerine (75 per cent.) with one volume of the suspected creosote, and shake well. Two layers will be formed when the mixture settles; one will be very muddy; the other somewhat less so.

The volume by which the last layer has been decreased is approximately that of the phenol present; in order to ascertain it definitely, we must increase the layer of the 75 per cent. glycerine by an equal quantity of the same glycerine and shake the whole well. The phenol passes into the glycerine up to 98 per cent.; or we can shake up the creosote with 5 per cent. of caustic ammonia, which dissolves phenol but not creosote from beech tar.

Graetzel and the writer both observed that creosote when agitated with glycerine almost doubled its volume. But, with an undoubtedly genuine specimen before us, we cannot obtain this increase of volume, and this change cannot therefore be regarded as an indispensable mark of beech tar creosote.

These two tests (1 and 2) with anhydrous and 75 per cent. glycerine indicate whether we have genuine creosote, but two reactions are yet required to fully prove it. 3. Equal volumes of creosote and soda lye (of 1·334 specific gravity) are mixed together to ascertain the wood tar particles. With a very slight degree of heat development there is a clear yellow solution. If the mixture is not clear and transparent, or has another color, or when it stiffens to a non-liquid mass, the creosote is not pure, if it be present at all. No. 1 gave a muddy whitish, and No. 8 a grayish brown mixture, which thickened after the lapse of half an hour. The remaining non-creosote specimens gave light lemon, dark lemon, or brownish yellow mixtures. No. 4 gave a red mixture, and contained 9 per cent. of non-creosote matters.

The new German *Pharmacopœia* gives a variation of this lye reaction. The soda lye of 400 specific gravity and creosote mixed by equal parts of weight should give a clear liquid (it may be yellow), but must not be dark colored or throw off bad-smelling tar when diluted with water. According to this test, three kinds of non-creosotes, Nos. 1, 2, and 3, genuine creosotes, and only No. 8 gave a dark colored muddy mixture. Testing with a soda lye of 1·334 specific gravity is therefore to be preferred.

4. Beech tar creosote gives a clear solution in petroleum benzine. A mixture of 1 volume creosote and 2 volumes of benzine is almost colorless or yellowish, but perfectly clear. Neither phenol nor creosol is soluble in benzine, and creosote gives a rather muddy mixture with even 5 per cent. of this phenol, which, after settling an hour, separates into two layers. This benzine solution, when transparent, is divided into three portions. The first is decomposed by an equal volume of caustic ammonia; the second by a lye of caustic soda of 1·160 specific gravity, and both parts are well shaken. No dark coloring, dark brown, or crimson should show itself in the course of half an hour. The third portion is (according to Hartmann and Hauers) mixed and shaken up with an equal volume of caustic baryta water. In this case neither blue, violet, nor red color should appear. It is immaterial in what layer, the aqueous or the oily, the coloration is; they indicate tar components which should not be present.

5. Mix 1 volume of creosote and 2 volumes of a 15 to 18 per cent. caustic ammonia, shake well, and put aside. The genuine clear creosote will, in the course of half an hour, be colored almost a lemon shade, and an aqueous layer on top will be yellow, gray, or some pale color. A dark color indicates foreign bodies, and if the volume of the creosote has diminished, it contains phenol, creosol, or kindred matters that do not belong, however, to creosote. The test can be made with even a 10 per cent. caustic ammonia, but a double volume is then requisite.

6. Equal volumes of collodion and creosote should not form into a jelly, but should rather become a liquid mass after half an hour; in the contrary case more or less phenol is present.

The first three or five tests are sufficient for true creosote, so that the other reactions may be dispensed with.

A creosote that does not comport itself as such should not be used, at least inwardly. Some of the kinds may be admitted for external veterinary use, but must not be classed as genuine.

Doses should be as small as possible, but often repeated. Proper doses for an adult are 0·02 to 0·03 and 0·04 two or three times daily. The maximum single dose is 0·05, and the maximum for a day 0·2. The pilulæ Kreosotatæ contain 0·0167 g. in each pill (*Ph. Centralh.* 1881). Consumptives in the last stage may take two or three of these pills two or three times a day, according to bodily size, and if they feel tolerably well after some days' use they should take two or three pills uninterruptedly night and morning, dropping them, perhaps, one or two days a week.

Pure creosote is pale yellowish, exudes oil, and is of 1·06 specific gravity. The gravity should be fixed at 1·050 to 1·060, as the lighter creosotes were either impure or not properly such.

Creosote is best administered in pills. The pilular mass is made by melting together 2 parts of yellow wax and 1 part of creosote, to which other suitable ingredients are added in form of powder, as quinine salts, salicylic acid, bals, solution, rad. gent., etc. Any addition of ether or spirits of wine to give consistency to the mass should be avoided, and is not necessary.

A lukewarm mixture of 7·3 creosote and 15·0 cera flava can, however, be mixed with 40·0 or 45·0 of the powder, so as to form a good pilular mass.

* Translated for *The Weekly Drug News* from *Deutsch-Amerikanische Apotheker Zeitung*.

REPORT UPON CREOSOTE.*

By Prof. P. W. BEDFORD.

THE object of this query can be but one, namely, to inquire whether the wood creosote offered for sale is a pure article or not; and if not, what is the impurity present.

The relative commercial value of the articles sold as coal-tar creosote and wood creosote disposes of the question as to the latter being present in the former article, and we are quite certain that the cheap variety is nothing more or less than a phenol or carbolic acid. Wood creosote, it has been frequently stated, is adulterated with coal-tar creosote or phenol. The objects of my experiments have been to prove the identity of wood creosote and its freedom from phenol.

The following tests are laid down in various works as conclusive evidence of its purity, and each has been fully tried with the several samples of wood creosote to prove their identity and purity, and also with phenol, sold as commercial creosote or coal-tar creosote, and, for comparison, with mixtures of the two, that even small percentages of mixture might be identified, should such exist in the wood creosote of the market.

The following tests were used:

1. Equal volumes of anhydrous glycerin and wood creosote make a turbid mixture, separating on standing. Phenol dissolves. If three volumes of water be added, the separation of the wood creosote is immediate. Phenol remains in permanent solution.

2. One volume of wood creosote added to two volumes of glycerin; the former is not dissolved, but separates on standing. Phenol dissolves.

3. Three parts of a mixture containing seventy-five per cent. of glycerin and twenty-five of water to one part of wood creosote show no increase of volume of glycerin, and wood creosote separates. Phenol dissolves and forms a clear mixture. Were any phenol present in the wood creosote, the increase in the volume of the glycerin solution, if in a graduated tube, would distinctly indicate the percentage of phenol present.

4. Solubility in benzine. Wood creosote entirely soluble. Phenol is insoluble.

5. One per cent. solution of wood creosote. Take of this ten cubic centimeters, add one drop of a test solution of ferric chloride; an evanescent blue color is formed, passing quickly into a red color. Phenol gives a permanent blue color.

6 Collodion or albumen with an equal bulk of wood creosote makes a perfect mixture without coagulation. Phenol at once coagulates into a more or less firm mass or clot.

7. Bromine solution with wood creosote gives a reddish brown precipitate. Phenol gives a white precipitate.

All tests enumerated above were repeatedly tried with four samples of wood creosote sold as such; one sample of Morson's, one of Merck's, one evidently of German origin, but bearing the label and capsule of an American manufacturer, and one of unknown origin, but sold as beechwood creosote, German, and each proved to be pure wood creosote.

Two samples of commercial creosote which, from the low cost, were known to be of coal-tar origin, gave the negative tests, showing that they were phenol.

Corroborative experiments were made by mixing ten to twenty per cent of phenol with samples of the beechwood creosote, but in every case each of the tests named showed the presence of the phenol.

The writer on other occasions applied single tests (the collodion test) to samples of beechwood creosote that he had an opportunity of procuring small specimens of, and satisfied himself that they were pure.

The conclusion is, that the wood creosote of the market at the present time is in abundant supply, is of unexceptionable quality, and reasonable in price, so that there is no excuse for the substitution of the phenols commonly sold for it. When it is directed for use, for internal administration (the medicinal effect being entirely dissimilar), wood creosote only should be dispensed.

The general sales of creosote by the pharmacists are in small quantities as a toothache remedy, and phenol has the power of coagulating albumen, which effectually relieves the suffering. Wood creosote does not coagulate albumen, and is, therefore, not so serviceable. This is, perhaps, the reason that it has become, in a great measure, supplanted in general sale by the coal-tar creosote, to say nothing of the argument of a lower cost.

* Read at the meeting of the American Pharmaceutical Association, Niagara Falls, 1881.

THE ADULTERATION OF OLIVE OIL.

By CH. MARIE.

THE oils which are commonly used to adulterate olive oil are very few in number. Among the most important are the colza oil, sesame oil, cotton seed oil, and peanut oil.

1. *Colza Oil.*—Independent of the conventional methods known, the presence of this fraudulent admixture may be easily detected by means of the sulphur contained in the cruciferous seeds, which must be offered as evidence. For this purpose ten grammes of the oil to be tested are saponified in a glass capsule, by means of an alcoholic solution of potassium hydrate (caustic potash) freed from hydrogen sulphide. The mixture is then agitated with a silver spatula which, becoming black, indicates the presence of an oil from one of the cruciferous plants, containing sulphur.

2. *Sesame Oil.*—To the oil which is to be examined there is added equal parts of hydrochloric acid of 23°, which has been slowly sweetened, then strongly agitated. The presence of the sesame oil is shown, no matter how small the quantity is, by a red coloration which is produced, and remains, when allowed to rest, at the bottom of the liquid.

3. *Cotton seed Oil.*—To the suspected sample of oil there is added an equal volume of nitric acid of 40°. When the mixture is strongly agitated, it assumes a *café au lait* color, more or less dark.

4. *Peanut Oil.*—The presence of this adulterant is difficult of detection, but, if the operation is slightly complicated, the fraud is not of frequent occurrence on account of the disagreeable taste of the product. In this case the oil to be examined is treated by an alcoholic solution of potassium hydrate. The saponified mass thus obtained is heated in order to drive off the alcohol; then it is treated with a quantity of hydrochloric acid sufficient to neutralize the potash. The fatty body which floats on the surface is arachnic acid.

This is collected, and dissolved in boiling alcohol, from which, when cooled, the arachnic acid is thrown down as a white mother-of-pearl precipitate, which is readily recognized.

Such are the ordinary tests that are used in the municipal laboratory at Marseilles for the detection of adulterations in olive oil. To the above we add a few other adulterants, giving the ordinary and easiest methods for their detection.

The adulteration by poppy oil is of quite frequent occurrence in the north of France, on account of the cheapness of this article; its neutral and soft taste makes its presence almost unnoticeable in a fraudulent mixture.

A good test, based on the difference of the viscosity of the two oils, consists of the introduction, with rapid agitation, of bubbles of air into the suspected oil. If it is pure, the bubbles will quickly pass off. In the contrary case they go to the surface, and there they remain during a greater or shorter period, forming a wreath.

If the mixture is heated to boiling, the poppy oil becomes covered with an abundance of froth, a circumstance which does not happen to pure olive oil. The freezing by means of a refrigerating mixture likewise offers a method of testing. The pure olive oil freezes between + 6 degrees and + 8 degrees. Poppy oil, on the other hand, does not solidify till —8 degrees to —12 degrees, forming an opaque whitish mass.

Olive oil mixed with peanut oil at + 8 degrees deposits particles resembling grains of sand, which sink to the bottom of the vessel, leaving the upper liquid perfectly clear. Whereas, when olive oil is cooled down to + 4, it concretes, and the particles remain suspended in the liquid.

Sulphuric acid is likewise of value in recognizing the purity of olive oil.

If a drop of sulphuric acid marking 66 degrees Baumé is added to ten or fifteen drops of oil in a colorless glass over a sheet of white paper, after a short while a coloration is developed, which varies according to the kind of oil examined.

Olive oil: light yellow, turning into yellowish green.
Poppy oil: canary yellow, then a dull yellow.
Peanut oil: yellow, dirty gray.
Sesame oil: bright red.

The adulteration of olive oil by means of honey is practiced more especially in Provence. For its detection the suspected oil is treated with water, then evaporated; after which the oleaginous portion is separated from the part dissolved by the water. This then has a sweetish taste which it does not have when in contact with pure olive oil, thus proving it to be of totally different origin.—*Jour. des Connaissances Utiles.*

[ANNALS OF ANATOMY AND SURGERY.]

THE RECENT CONGRESS OF GERMAN SURGEONS.

THE transactions of the recent congress of German surgeons having appeared in condensed shape,* we are justified in devoting some space to a consideration of its labors. Without speaking in detail of each paper, we deem the following as most noteworthy:

NAPHTHALIN.

Fisher (Strassburg) deals with the naphthalin so largely used in Luecke's clinic as a substitute for carbolic acid and iodoform. He claims for it equality of antiseptic power with other drugs, and special and almost specific power against erysipelas; a very important fact, if substantiated. Naphthalin is very cheap, and gauze, prepared either by rubbing in the powdered material or soaking in an ethereal solution diluted with alcohol, thus impregnated with it will prove much cheaper than anything else of the kind now in the market. As thus used in Strassburg, it gives eminently satisfactory results; and it is to be hoped will soon be generally introduced into this country.

PEAT OR BLACK EARTH.

Neuber speaks highly of the antiseptic virtue of peat or black earth, which is filled into bags made of loose gauze and laid over wounds, being held in place by gauze bandages. As used in Kiel, the dressing is seldom changed, or not at all. He considers that the turf absorbs all secretions rapidly, and by its porosity favors their evaporation, while healing takes place as under a scab.

CORROSIVE SUBLIMATE.

Kümmell (Hamburg) recommends corrosive sublimate. Following an idea of Koch's, he employs it in solutions of 1 to 1,000 or 5,000 for irrigation. In all his experience, symptoms of absorption—slight salivation—appeared only in two decrepit individuals. The same solution is employed for the hands, sponges, and compresses; while silk and catgut are prepared with it. Instead of Lister gauze or cotton, that prepared in a half per cent. solution of sublimate is employed. He has, moreover, used sand, ashes, and glass wool, which have been first heated and then treated in an ethereal solution. The glass wool thus prepared is often of the greatest service for drainage. Dressings of this kind may be allowed to remain from seven to ten days. He had had an amputation of the thigh heal by first intention in thirteen days under this dressing. A table of two hundred cases, where no other antiseptic had been employed, gives happy evidence of his success.

IODOFORM.

Langenbeck (Berlin) makes a long communication concerning iodoform. The subject has become rather a tiresome one, and it is unnecessary here to devote space to it. His whole paper may be summed up in one of his first statements—that iodoform should not be given up simply because it may do harm, but that more judgment should be displayed in its use.

MUSCLE GRAFTING.

Helferich (Munich) reports a case in which he removed a large muscular tumor from the body of the biceps muscle. The large defect thus left was filled with a corresponding mass of muscle from the biceps femoris of a dog, the whole being done under Lister. Three months afterward the muscle contracted almost as well as before.

PARTIAL RESECTION OF THE TEMPORAL BONE.

Gluck (Berlin) reports a partial resection of the temporal bone. He chiseled away the anterior third of the mastoid process, the posterior half of the petrous, and a part of the squamous portions. On opening the dura mater, sixty grammes of fetid pus escaped. The wound was drained, and dressed with iodoform. The trouble had been a chronic otorrhœa, leading to intra-cranial suppuration. Gluck would recommend a similar procedure in cases of caries of the petrous portion, or for ligature of the carotid in its canal in cases of cerebral aneurism.

AFTER TREATMENT OF EXTIRPATION OF THE LARYNX.

Schede (Hamburg), alluding to the perplexities in the after treatment of extirpation of the larynx, considers that the two great difficulties are these: The prevention of septic pneumonia from wound secretions, and artificial nourishment in those cases where a considerable portion of the œsophagus has been removed. The former he overcomes by the tracheal canula devised by Michael (and demonstrated by him at this same congress), which is covered with rubber in such a way as to completely fill the trachea. The latter difficulty he obviates by using a syringe constructed with a nozzle which may enter the upper end of the œsophagus. The syringe is filled with the more or less fluid nourishment, which is thus injected into the stomach.

OPERATIONS ON THE THORACIC VISCERA.

Block (Dantzic) gives the results of his researches as to the possibility of certain operations on the thoracic viscera. He has a number of times opened the thorax in dogs, and sewed up purposely made rents in the heart muscle, after laying the pericardium freely open. The fact that numerous animals survived such radical interference may be regarded as a prophecy as to what the surgeon may yet accomplish.

RESECTIONS OF THE LUNGS.

He also reports his results in some fifty or sixty resections of the lungs, and has been able to demonstrate his success on a number of dogs and puppies which have survived—many of them several months—the removal of from one to four pulmonary lobes, and which were all in apparently perfect health. In larger animals, in whom the conditions are more like those in man, the results are particularly good, as well as in the tuberculous. The operation is very short, and under antiseptic dressings recovery may be expected without suppuration. The resulting pneumo-thorax exercises no bad influence on the progress of the case. Clinical cases are known where marked deficiencies of the lungs have existed without the patient suffering therefrom; while Weinlechner has removed a whole lobe with good result. Indications for resection of the lung are hemorrhages, tumors, foreign bodies, gangrene, abscess, and phthisis, when it is definitely located.

ŒSOPHAGOSCOPE AND GASTROSCOPE.

Mikulicz (Vienna) gives an account of his researches with the œsophagoscope and gastroscope, with demonstrations on the living. As we hope to present this subject more *in extenso* in a subsequent number of the *Annals of Anatomy and Surgery*, we omit further reference to it here.

RESECTION OF THE PYLORUS.

Lauenstein (Hamburg) recounts a case of resection of the pylorus, patient dying on the eighth day. In his case it seemed to him that the localized gangrene which caused the death was to be accounted for by lack of necessary nutrition from vessels which had to be ligated during the operation.

Rydygier (Culm) also reports at length his successful case of pylorus resection for ulcer, already made famous; the diagnosis and result having been equally happy.

REMOVAL OF THE SPLEEN.

Crede, Junior (Dresden), reports a successful removal of the spleen, for enlargement, following injury. In the discussion which followed, allusion was made to six other cases by different operators, of which but one recovered.

LAPAROTOMY ABOVE POUPART'S LIGAMENT.

Rosenbach (Göttingen) relates how, in a case of cancer high up in the rectum, he made a laparotomy above Poupart's ligament, drew out the sigmoid flexure, ligated it twice, and cut it between the ligatures. Having cleaned both ends, he made an artificial anus with the proximal end in the groin; the lower he replaced. The extirpation of the lower portion of the rectum was then undertaken in the usual way from the perineum, a number of implicated retro-peritoneal glands being also removed. The resulting cavity was packed with iodoform gauze. Death resulted from collapse on the second day. He also reports interesting cases of retro-visceral dermoid cyst, congenital neuroma of the solar ganglion, and abscess of the pancreas.

SUTURE OF THE BLADDER.

Sonnenburg (Berlin) and Julliard (Genf) both have interesting papers on suture of the bladder, made necessary by injury of that organ during ovariotomy. Papers also by Schede and Hahn on genu valgum and resection of the knee are worth mention, though space fails for even a brief abstract of them.

We have called attention above only to those communications which seemed most novel or interesting. The discussion evoked was often as valuable as the papers themselves. If the results of this congress show one feature more than another, it is that the Germans still maintain the lead in the matter of surgery of the viscera. While the peculiar relations of the surgeon to patients, in Germany, may explain this to a certain extent, it in no wise diminishes the tribute of respect we owe to those who have had the tact to devise, and the good fortune to successfully carry out many of those operations whose boldness has commanded the admiration of American surgeons, who, perhaps, will never have the opportunity or the courage to repeat them.

ROSWELL PARK.

* Beitrage zum *Centralblatt für Chirurgie*, No. 29, 1882.

OBSCURE CASES OF INEBRIETY.

By T. D CROTHERS, M.D., Hartford, Conn.

IN all etiological studies of inebriety, there are certain cases whose physiological history is involved in mystery. The first use of spirits was obscure, and grew so gradually that it escaped all notice. Such cases have drunk spirits for a long time, without any intelligent comprehension of the reasons or nature of the act. When in the later stages attention is called to them, the theory of vice and sin is urged vehemently, on the supposition that any other view would take away personal responsibility and personal effort to recover. The delusion of strength to stop at will, so common in all of these cases, is stimulated by this theory, and the method of prayer and pledge is readily adopted. Henceforth they are alternately buoyed up on this delusion of self control and help from the pledge and prayer, or depressed with the utter hopelessness of all means. Any vague impression which they may have of a physical causation has no support from others, hence all physical inquiry is ignored. The old divine, Thomas Aquinas, in the twelfth century, describes the sin of inebriety as follows: "The whole life of a drunkard is a battle-ground in which the flesh and the spirit are contending for the mastery. Sometimes the drunkard is on the side of the flesh, then he joins the spirit, and the conflict goes on, either embracing the devil or casting him off. But the devil triumphs at last in most cases." This is the theory, slightly varied, urged to-day in explanation of many cases whose origin is not clear. In all ages of the world, the mysterious and that which could not be explained has been attributed to a spiritual origin. Hence inebriety has been referred to a low moral nature and to vice and sin. When from a better knowledge this theory was untenable, a compromise was made, and now it is urged that a stage of vice and sin is followed by disease. Or in other words, the inebriate is always vicious and sinful at first, and the result of gratifying this low moral nature is disease. This pernicious doctrine has put back the scientific study of inebriety for half a century. It is the obscure borderland cases, whose mystery has attracted clergymen and reformers, that have furnished support for these false theories. The presumption of the advocates of this doctrine, who insist on the vice origin of all cases whose chain of causes is not clear, is misleading and unnatural. If in ten cases of a similar disease the physical origin can be traced in five, it is most reasonable to suppose that a similar physical causation exists in the others, although not clearly traceable. Can any one doubt the physical origin of typhoid fever, insanity, or any other disease long known, simply because the causation in some cases is obscure? Inebriety is a more complex disease than insanity, and has never been studied thoroughly, but the natural history of some cases, starting from a well defined physical standpoint, passing over a regular course which can be traced from stage to stage, furnishes the best of evidence of physical causation and physical law, which a wider knowledge will make clear.

The following case is one in which the causation was clear and traceable: A——, a strong, vigorous merchant, aged thirty, with no heredity, and temperate, suffered from a partial sunstroke. He remained greatly debilitated for two months in bed, then began to use spirits to excess, and was a continuous inebriate up to death, four years later. He made great exertions to recover by the pledge and prayer, but failed and died of dementia. The drink craving was clearly traced to the brain injury from sunstroke. No possible causation of vice could be traced to the first use of spirits, and the progress of the case was regular in spite of all means to check it.

The next case is a borderland one, full of mystery, but when carefully studied has clear outlines of an unmistakable physical causation. B—— was born of healthy parents and grew up a vigorous man, temperate and correct in all his habits. He was a prosperous mill owner and attentive to business. At thirty-one years of age he married, and his wife was killed on the wedding tour in an accident. His grief was very profound; for two months he was unable to do any business except walk to the mill a few moments every day and direct some little matters. He took tonics under the direction of a physician, and complained generally of sleeplessness and poor appetite. A year after, he began to frequent low places and use spirits over the bar and associate with bad company. Later, he was intoxicated in public. Then he neglected his business, bought fast horses, and became dishonest, doing many things that were foreign to his previous character. Gradually he sank from bad to worse, and finally was sent to State prison for forgery. His property was gone, and he became a gambler and inebriate of a low type.

In this case the most prominent symptoms were low, vicious propensities seeking an outlet in bad society and drink. When the history was studied, it was clear that the shock of the sudden death of his wife produced a psychical traumatism; some change in the normal functional action of the nerve-centers, which became the starting-point of a general moral and physical degeneration; some loss of nerve-force, manifest clearly in departures from health and changes of thought and action. The sudden shock of grief produced permanent alterations of character. His disposition changed; all his previous motives and ambitions in life vanished. He left the church and began to lead a most irregular life, giving no reason except that he was discouraged. At times he seemed to manifest grief at his conduct, and made an effort to recover, but soon relapsed. His brain retained, during the sober moments, an appearance of health in thought and action. He talked and reasoned clearly, and made efforts to recover; signed the pledge; asked the prayers of the church; then, in the moment of greatest promise of success, fell precipitately into the lowest company and state of drinking. There was no reasoning or calculation in this; the mind seemed, at a certain point, to be incapable of forming any views of the subject, and to act under a diseased impulse that was beyond control. The radical change of character and of motive, beginning at a certain point, leading rapidly to ruin, pointed to a physical cause uninfluenced by any moral state previous to this time.

In the following case a similar obscure history was found, from a closer study, to spring from the same cause. He was a wealthy merchant who had by long industry amassed a fortune. He was temperate in all things, a man of much character and deliberation, a church member with a family, and very exemplary in conduct and honorable in business. No history of heredity in the family, and no spirits were ever used, partly from principle and an inherent dislike to their taste and smell. A financial storm made him suddenly poor; his wife died and his family scattered, all in a few months. His hair turned gray, and the shock of grief for a long time left strong marks of physical suffering. He resumed business again, but frequented low saloons and drank to intoxication. He was forty-eight years old at this time, and seemed to have the same intellectual force, only more quiet and reserved in his manners. He succeeded, but was noted for dishonesty and prevarication. Seemed to take pleasure in overreaching and deceiving others. He drank to excess every night, and was low in his tastes, company, and associates. Great efforts were made to reform him by his church friends. He seemed pleased with these efforts, and was rational in aiding them, promising with great earnestness to do all that was required, but in secret drinking and living as before, all efforts to conceal this becoming more and more imperfect. He gradually became worse, and was sent to Blackwell's Island for drunkenness and fraud several times in the next five years. He is now, ten years from the time of his failure in business, a hostler in a small hotel, drinking regularly, and a wreck in body and mind. This was clearly psychical traumatism, beginning at the time of his financial ruin, and marked by the changes of character, disposition, and conduct. His mind to the general observer gave no hint of such change. He reasoned with others clearly about himself, but was unable to carry out any plan when left alone. Two distinct beings seemed to exist, one that

would live a natural, healthy, pure life as before, the other that sought relief from alcohol and the lowest impulses of nature. As the latter grew, he could give no reason for this course except that he could not help it. He gradually failed, the mind becoming feeble with the body, and the one dominant impulse for alcohol seemed to supersede everything. A diseased condition of the brain centers was present. There was failure of co-ordination, or acting upon the impressions received or sent out from the central ganglion.

Psychical injury from varied causes are traceable in these obscure cases of inebriety, as in the following very common instances: A man with a neurotic inheritance receives a blow on his head, and soon after becomes an inebriate. He is confident that this concussion has broken up his health, although he may not trace inebriety to it. It may be in another case a sunstroke, followed by months and years of nerve debility; then inebriety comes on. Some latent inherited nerve-defect may spring into activity from the shock of grief, or sudden powerful depressing emotions. A man fixes all his hopes and ambitions on some special object in life, and suffers from sudden disappointment, the sweeping away of every expectation, followed by intense grief and sorrow, then inebriety. It is these psychical storms which not only break up the normal molecular action of the brain, but prepare the soil for inebriety in the future.

There is another form of traumatism, which is undoubtedly the cause of inebriety, that has never been noticed It may be termed physical, because it springs from disease and injury that is always apparent. A man has some injury or severe illness from which he recovers, but is never the same after. He is conscious that he has lost some element of force and vigor, and this event has been the switch or the point of departure from the main line of health. In many nameless ways this fact is apparent. Sometimes changes in disposition and character are apparent to his friends, in others want of physical strength and endurance are the prominent signs. Whether he is aware of it or not, changes both psychological and pathological may be traced from such events that merge into insanity, inebriety, or other disorders. A man previously modest and retiring, after an attack of typhoid fever, becomes boastful and assuming, and exhibits decided changes of character. Later he is an inebriate or insane, or has some form of paralysis. Although the direct chain of causation may not be clear back to the typhoid fever, yet there can be no doubt that this was the starting-point.

A patient now under treatment, with a history of ten years' drinking in fast society and bad surroundings, was found to have a period anterior to this as follows: Six years before he began to use alcohol his leg was broken in a railroad accident. An artery was wounded and severe hemorrhage followed, which threatened to be fatal. Convalescence was slow, and it was nearly a year before he could resume his business as bookkeeper. From this time his habits became more and more irregular, especially in eating and sleeping, also in work. He was depressed, and complained of neuralgia, and could not concentrate his mind on his work. Would take the correspondence home, and after a sleep in the night or early in the morning complete it. Was morbid in his credulity of patent medicines and efforts to find something that would bring relief. His mind seemed the same in his business, and his social relations were unchanged, and yet he was a nervous invalid or neurasthenic, suffering from some alterations of nerve-structure and function. The inebriety really began in this period in the favoring conditions and increasing degenerations, which at last developed into the drink craving. All superstitious notions of vice in the origin of this case disappeared when the history was understood, and a general outline chain of causes was traceable from the time of this injury.

Both of these forms of traumatism have been noticed as causes in inebriety by both English and German authors, but no study has been made of such cases, owing to the impression that they were rare, and always associated with insanity. A wider study will dispel this error. The evidence will appear, from a study of many of these obscure cases, fully sustaining this view of remote injuries to the brain and nerve centers, resulting later in inebriety. No matter how changeable and obscure the progress of the case may be, there will always be a certain regular progression or march from some point or event of life on to the full development. These physical and psychical storms either alone or together leave traces and marks that are seen all along the future. The normal vigor and integrity of organism is disturbed or broken, the great outer circle of health is left behind, and life goes on over the border of the shadowy inner circle where health and disease blend and contend.

John B. Gough, in his biography, mentions a severe injury received in childhood, followed by delirium, which, in his opinion, has influenced his entire life physically. This testimony, unconsciously given, of both a pathological and psychological state, is of great significance. The great practical facts, which may be demonstrated in the study of every physician, are that all these obscure cases of inebriety are suffering from disease, which is more or less curable if recognized and properly treated—an affection that cannot be reached by moral means or by appeals to pride or religious emotions, but only from the exact application of physical means suited to the wants of each case. This may be secured in most cases, but only from an absolute quarantine of the patient from every exciting cause. All the surroundings and conditions of life must be under the care of a physician, and every means known to science applied to build up and restore the lost energies.

The following conclusions will help to further studies in this field, and may be said to outline some leading facts from which the laws of this disease may be deduced:

First.—All cases of inebriety should be studied carefully to ascertain not only the heredity, but the possible history of traumatism, either psychical or physical. As in epilepsy scars on the scalp may often furnish clear indications of the chain of causes. Fevers and any disease or events which have profoundly influenced the organism and nervous system are always prominent factors in the history.

Second.—Inebriety is a central disease of the nervous ganglia, which may either follow a regular line of march down to chronicity or death, or be attended with uncertain halts, long pauses, or rapid progress, from some unknown causes; but, whatever its course may be, always following a certain order and regularity in the stages of degeneration, that is seen and may in many be predicted.

Third.—From a knowledge of the cases, the varied means of treatment can be applied which will be most effectual in restoration. If the case is chronic and incurable, such a study will point out the best means to limit and control its progress in the least harmful channels.

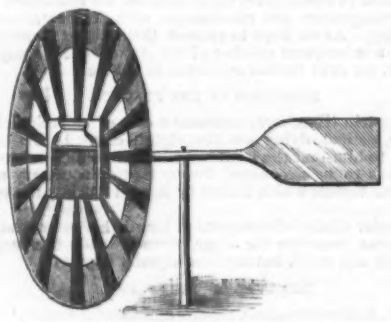
Fourth.—Inebriety and its problems must be studied by medical men above the superstitious theories of reformers and clergymen before we shall have any positive facts upon which to base accurate methods of treatment and cure.—*Medical Record.*

PREVENTION OF MOULD.

THE Rev. J. Tasker (*Entom.*, xv., 233) says that glacial carbolic acid is a perfect remedy for mould. Now, as this preventive will doubtless be tried by some of your readers, and as I suffered some years since from using it precisely in the manner described by your correspondent, and which, I may add, was recommended to me by good authority, I should like, by way of caution, to let others know the result of my experiment. The prepared pads of cotton wool were placed in my drawers of Lepidoptera. This was no sooner done than it was evident that mould could not exist in its company: but ere sufficient time had elapsed for me to thank my informer, and congratulate myself on the success obtained, I discovered another and more serious evil in connection with the whites, which in some instances were fast turning to a dirty cream color; this fact was most conspicuous with *Liparis salicis*, *Dysthymia acontia*, and *Melanippe hastata*, but, on the other hand, none of the Diurni had changed in appearance. Here was a curious problem, but one easy to solve, as the former species had been cyanized with spirits of wine possessing the orthodox proportion of corrosive sublimate, while the latter had not been so treated. A subsequent special experiment corroborated the previous result, and at once clearly demonstrated that either the use of glacial carbolic acid, or cyanizing insects which happened to have white upon them, must be abandoned.—H. T. Dobson, Jr., New Malden, Surrey, Oct. 21, 1882.—*The Entomologist.*

CHURNING WITH THE WIND.

DR. G. P. HACHENBERG, Travis Co., Texas, has a "churn" which he describes as follows: "I place the cream in a large glass air-tight jar, about two-thirds full, and adjust the jar in line of the axis of a windmill, swung low to the ground, as shown in the engraving herewith. The jar is placed inside of a box, which keeps the cream cool as well as in its proper place. In very hot weather, ice wrapped in woolen cloth may be placed within the box, around the jar. As the windmill revolves, the jar turns with its axis, thus keeping up an agitation of the cream until the churning is effected. A convenient method to churn by this process is to put the



A WINDMILL CHURN.

cream in the jar in the evening, and remove the butter in the morning. The butter is not only made, but thoroughly worked, and taken out in a fine firm ball. We might call this the tumbling process."—*American Agriculturist.*

CORN.

WHATEVER may have been in the past, there can now be no denial of the fact, said Mr. Halsted, before the Massachusetts State Board of Agriculture, at Northampton, in his recent lecture on corn, that "Corn is King." The yield in the United States the present year, can fall a little short of two billion bushels, of which amount Massachusetts produced about two million bushels. It was in this State that the first field of this grain was ever planted by civilized man, but so plastic is the nature of the plant that it is now grown over a very wide extent of territory, and its culture has become a leading branch of our American agriculture. It is probable that the many varieties now grown originated from a single variety which was as much inferior to those we are now familiar with, as was the wild savage who planted it to the best farmers of to-day. A classification of the varieties is a little difficult, but corn is distinguished under the names of flint, Dent, pop, sweet or garden, field, and hard and soft. There is also a variety in which the kernel is inclosed in a husk, this by some being considered the original type. The rows vary from four to forty, and are always of even number. The kernels are of various shapes, and of many shades of color, from white to nearly black. The vital portion is in the chit, the tender part chosen by mice, and from which the young spire starts when planted. The remaining portion, chiefly starch and oil, serves as food for the young plant before it can draw its nourishment from the soil. Corn, like other agricultural plants, has its three systems—roots, stem, and leaves. The roots are provided with infinite numbers of little root hairs, which are the real feeding organs, and which require a very fine, mellow, and rich soil in order that the plant shall attain its highest possibilities. The corn crop is produced in about one hundred days, growing but little in cold weather, but very rapidly in hot days after showers. As the annual value of the crop of the country is about $760,000,000, the average daily increase during the season of growth is some seven millions, but in days of extra growth the farmers who are sweating in the field may comfort themselves that every such hot day is adding about $20,000 000 to the wealth of the United States. Its growth may be divided into three stages—the germinative, vegetative, and reproductive. The sexual organs are on different parts of the stem, the male flowers, yielding pollen dust, being at the top, the silk and ear lower down on the stem.

The diagrams exhibited at the rear of the platform, and showing the method of growth from the swelling seed to the fertilization of germ through the influence of the pollen grains working themselves down through the interior of the silk, added much to the entertainment of the evening. The annual average yield throughout the country is far below the possibilities of the plant. Much may be done to increase the product by a better selection of seed, and by growing corn specially for the seed. One fine ear of good shape and length is far better than several small and inferior ones. A model ear has a small cob that can be easily broken from the stalk at harvest, soft husks, and the kernels uniform and well capped out at the tip. In selecting or growing seed, prolificacy is of great importance. Too much corn is grown of varieties that can never yield very great crops. Hybridizing, or the crossing of selected varieties with care and good judgment, may be the means of accomplishing much in this direction, and the person who is so fortunate as to produce a variety of double the value of the best now grown will doubtless be well rewarded. America is the peculiar home of the corn plant. England would give a thousand fortunes could she grow corn as successfully as it is grown here.—*N. E. Farmer.*

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